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POWER

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Two Ways

THE National Association of Stationary Engineers is started upon the last decade of a half century of existence.

It was, at the time of its organization, unique among trade or craft organizations in that instead of restricting and circumscribing the knowledge of its subject it sought to broaden and disseminate it, and instead of seeking to control the available labor supply in its line it left its members free to govern their own relations with their employers. And now, after more than forty years, what is the outcome?

There are those who say that the idea of the improvement of individual qualifications as a means of bettering one's condition has failed to prove its superiority to the method of collective bargaining.

Ordinary craftsmen of well organized unions often draw more pay than the power-plant engineer who employs them.

For them, and from the point of view of immediate pecuniary return, their system is the better; but what would happen if it were universal?

If everybody got twice as much wages or salary as he does now, everything would cost twice as much and nobody would be any better off.

The aged laborer living upon his savings or on a fixed income would be worse off because the dollar which he had saved years before would buy only one-half as much as it would then.

The successful union strikes not against its employer, but against the users of its product.

And the most of these are its fellow laborers in other crafts.

It is a question of relativity.

The craft that gets organized quickest and strongest has a temporary advantage over all other crafts. Everybody who builds or pays rent or buys anything that is made or stored or sold in a building pays the exorbitant wages of the well organized building trades.

Conducted upon this plan industrial relations will degenerate into a strife of craft against craft and will lead nowhere.

The N.A.S.E. way is comparable rather with that of the high-minded medical association that seeks to eradicate the diseases upon which its members thrive and looks for progress and preferment for the profession through the service that it can render to humanity.

F. R. Low

Care of Power Transformers

Testing and Maintaining the Oil in Good Condition—Cleaning the Water-Cooling Coils and Testing for Leaks—Making Inspections and Precautions To Be Observed

BY RALPH BROWN*

BECAUSE present-day transformers are of substantial construction and reliable, there is a tendency to assume that it is only necessary to maintain the oil at the normal level and to avoid exceeding the limiting temperature, but such an assumption may lead to serious operating difficulties.

Considering oil-insulated transformers, the dielectric strength of the oil must be maintained at a high value, and this requires that samples be drawn from the lowest part of the tank at regular intervals, preferably monthly, and tested to determine their breakdown value. The standard breakdown value for transformer oil is 22 kilovolts with a 0.1-in. gap between disk terminals 1 in. diameter, which is the new standard, or 40 kilovolts with a 0.2-in. gap between ½-in. disks, the old standard. The average of five tests should be taken as the breakdown value, and printed forms should be provided for recording the test data, which should be filed for future reference. Consistent results cannot be expected if the samples drawn from different transformers are mixed, hence an individual quart bottle, provided with a neck of large diameter and a glass or cork stopper, should be used when sampling oil. The station number of the transformer should be etched or painted on the bottle, which should be kept on a suitable shelf near the transformer when not in use. If a standard oil-testing outfit is not at hand, one may be improvised if a transformer from which 22 kilovolts can be obtained is available. If facilities are not available for testing oil, quart samples should be sent to the transformer manufacturer for testing. If the oil punctures at less than 17 kilovolts with the 0.1-in. gap, or at 30 kilovolts with the 0.2-in. gap, its dielectric strength should be brought to normal without delay by using a filter press or a centrifugal purifier. As an indication of the breakdown values that may be expected in practice, the average voltage required to puncture samples of oil drawn from six large water-cooled transformers in continuous service for two years was 32 kilovolts.

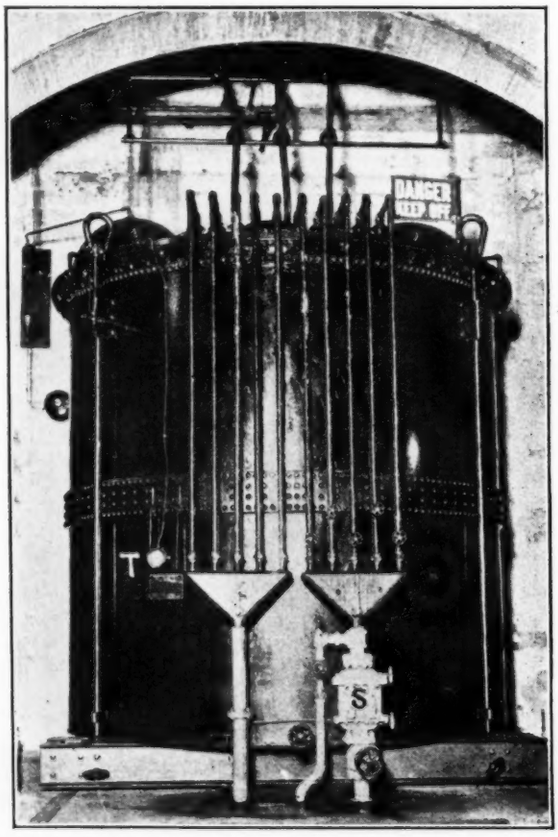

FIG. 1—LARGE WATER-COOLED THREE-PHASE POWER TRANSFORMER.

At *S* is shown a strainer in the cooling-water line, and the thermometer for obtaining the oil temperature is located at *T*. Red and green lamps are provided and connected in such a way as to give the attendant an indication how to regulate the supply of cooling water.

Effects of Water in Transformer Oil

The most common cause for a decrease in the dielectric strength of transformer oil is the presence of water, 0.01 per cent of which will cause a marked decrease in its insulating qualities. Owing to breathing action, which results from the contraction and expansion of the air above the oil in response to temperature changes caused by variations in the load, particularly in a humid atmosphere, moisture will be drawn into the tank through any opening present and mix with the oil. To avoid the entrance of water from this cause large transformers have but one opening, to which a breather is connected. This breather contains anhydrous material, such as calcium chloride or quicklime, which will abstract much of the moisture in the air entering the transformer. The breather should be inspected periodically and cleaned and refilled when about two-thirds of the chemical has dissolved. In the conservator type of tank, Fig. 2, any moisture that passes through the breather will settle in the small tank, and the pet cock provided should be opened periodically to draw off any water that may have collected. Where safety diaphragms are provided to avoid abnormal tank pressures, such as might arise from internal arcing, they should be kept airtight, so that any air entering the tank must pass through the breather. When assembling the conservator type of tank, especial care must be taken to use suitable cement and gaskets, such as can be obtained from the manufacturer, in order to avoid annoying leaks.

In water-cooled transformers the turns of the cooling coils within the tank above the oil are lagged to minimize condensation, this lagging usually consisting of two or three layers of heavy cotton tape, well var-

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nished or shellacked. An internal inspection should be made annually to determine if the lagging is intact, for the dielectric strength of the oil will be decreased if the lagging is allowed to deteriorate. In the conservator type of tank the cooling coils are not insulated, since they are immersed in oil.

Leaks Develop in Cooling Coils

If, as rarely occurs, a leak develops in the cooling coils, the water will generally settle in the bottom of the tank, and several gallons may leak into the tank without appreciably lowering the dielectric strength of the greater portion of the oil. Samples of oil should always be drawn from the extreme bottom of the tank, for the earliest indications of water will be found there. While large high-voltage transformers have operated for considerable periods despite the presence of several gallons of water in the bottom of the tank, the slightest indication of moisture in the oil is a definite danger signal. The extent to which the resistance of the insulation has been lowered due to the presence of water can be found by meggering the insulation between the low- and high-voltage windings and between each winding and the core, before the insulator materials have cooled sufficiently to absorb additional moisture. By comparison the values of the resistances so found with those obtained when the transformer was known to be thoroughly dry, the condition of the insulation can be determined.

When water is detected, it should be drawn off at once and a pressure test made on the cooling coil. Such a test can be made by draining the coil, blowing compressed air through it to insure dryness and filling the coil with transformer oil. With one end capped and a pressure gage connected, the pressure should be brought

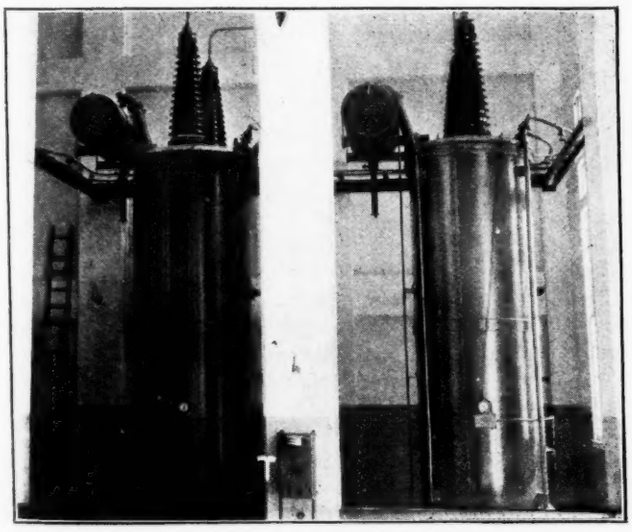


FIG. 2—TWO LARGE SINGLE PHASE TRANSFORMERS OF THE CONSERVATOR-TANK TYPE
Conservator tank is shown at left above main tank. An electrical temperature indicator is shown on the small panel at T.

to 200 per cent of the maximum working pressure. Assuming that all fittings are absolutely tight, the pressure within the coil should remain unchanged except for variations in the ambient temperature, for at least four hours, if the coil does not leak. By using oil in making this pressure test, the insulating qualities of the oil in the tank will not be impaired if the cooling coil fails. If the test indicates that a leak exists, it may be necessary to lower the oil level in the tank below the lowest part of the coil, and a careful inspection will often be required to locate a slight leak. Some leaks can be repaired with the cooling coil in the tank, but due to restricted space it is generally necessary to remove it. When removing the transformer from the tank, care

FIG. 3—EFFECTS OF A SHORT-CIRCUIT ON A TRANSFORMER COIL

must be taken to avoid damaging the cooling coils. Unless metal strips are attached to the cooling coil to prevent rubbing and cutting, such strips should be on hand for use when the core is to be handled. Cooling coils should be tested for leakage just before the transformer is placed in service and annually thereafter. When a transformer is taken out of service, to avoid the danger of freezing the cooling coil should be drained and dried with compressed air.

Removing Scale From Cooling Coils

At suitable intervals, depending entirely upon the scale-forming characteristics of the cooling water, the amount of water, at a standard pressure, flowing through each coil should be measured by a flow meter or by temporarily diverting the discharge into a measuring tank, at the same time noting the water temperature at the inlet and outlet. By referring to this data, which should be recorded on a suitable form, the condition of the cooling coils can be readily determined and cleaning properly scheduled. Scale is usually removed by filling the coil with a solution consisting of equal parts of commercially pure concentrated hydrochloric (muriatic) acid and water, and after standing about one hour, the coil is thoroughly flushed out with water. This process is repeated until the scale is completely removed. As there is a possibility of the solution causing leaks to develop in the brazed joints, the cooling coil should be tested after the removal of the scale. After a transformer has been in operation a few months, sludge is usually deposited on the outside of the cooling coils, and

this should be removed by using gasoline or oil, or scraping and brushing.

Since certain inspections cannot be made unless part or all of the oil is drained from the tanks, an oil-handling system should form part of any transformer installation of consequence. Preferably, two storage tanks, one to be used for clean and the other for dirty oil, each of sufficient capacity to hold all the oil in the largest transformer, should be provided. The piping should be arranged so that the oil can be drawn from and forced into any tank, but before using oil delivered by a system of piping, care must be taken to flush out any entrapped water. Oil is usually forced into the transformer tanks by means of compressed air, and safety valves should be connected to each storage tank to prevent excessive pressures. After a transformer is filled with oil, it should not be placed in service until all air bubbles have come to the surface and a breakdown test indicates that the oil is dry. An oil gage with a scale marked in the twentieths of a foot should be connected to each storage tank, and as a check on possible leakage the amount of oil on hand should be recorded monthly. In order that corrections for temperature can be applied, thermometers should be attached to the storage tanks.

Facilities for Handling Transformers

The tanks of large transformers are placed on trucks to facilitate moving, and an eyebolt or hook should be placed so that a crane, if one is available, or chain blocks can be utilized to move the transformer. Slings, clevises and eyebolts should be kept in readiness for properly handling any part of the transformer, and special ladders that can be passed through the manhole should be provided. If a repair pit is used, sockets should be placed in the floor and a portable railing erected before the tank cover is removed. If work is to be done on top of a transformer above the floor, a railing should be bolted to the cover. Ladders should be made secure at the top and bottom. Special precautions must be taken when removing nuts, bolts, etc., to prevent them from falling into the transformer, and all tools used about an open manhole or within the tank should be attached to a cord or a metal chain. Before a tank is entered, all objects which might possibly fall from the pockets should be removed, for if a coin or knife is dropped, complete dismantling of the transformer may be required to permit of its absolutely necessary removal.

After a few months' service the oil level should be lowered sufficiently to examine the terminal board connections, since these may become loose, due to vibration, and contraction and expansion. Instances are known of conductors' burning apart within the oil because of heating caused by a loose connection, and it is recommended that lock washers be used with all bolted transformer connections.

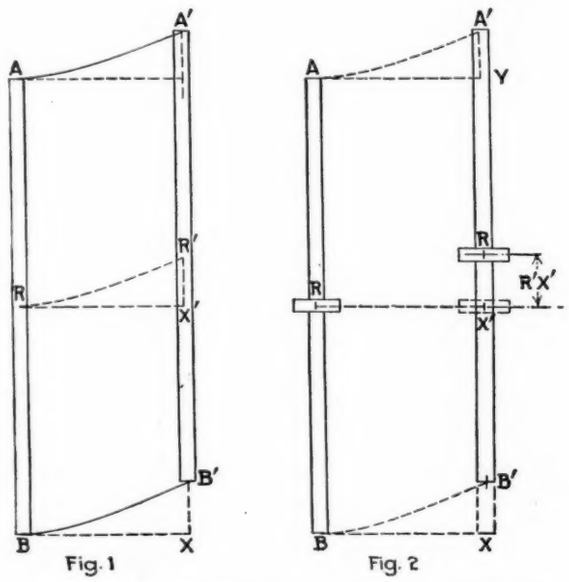
The windings and core should be examined annually for indications of sludge, and if present, it should be removed by using a jet of insulating oil, to prevent the occurrence of hot spots because of clogged oil ducts. After the sludge is removed, the oil should be filtered before it is returned to the tank.

Don't place a valve in an ammonia line in such a way that the flow of liquid or gas tends to close it. Don't fail to keep oil out of the expansion coils.

Why You Can Measure the Area of an Indicator Diagram by a Planimeter

The mean average height of an indicator diagram may be measured fairly closely by the several mean ordinate methods. Such methods are laborious, and if many diagrams are to be measured, some form of planimeter is desirable.

A planimeter, as the name indicates, is a meter with which to measure areas or planes. While several types are in use, all make use of the same general principles. Although several pages might be filled with a mathematical discussion of the theory on which the instrument is based, this is not necessary, and a simple graphical proof, originally outlined by A. Jamieson, will prove that the planimeter can measure areas.



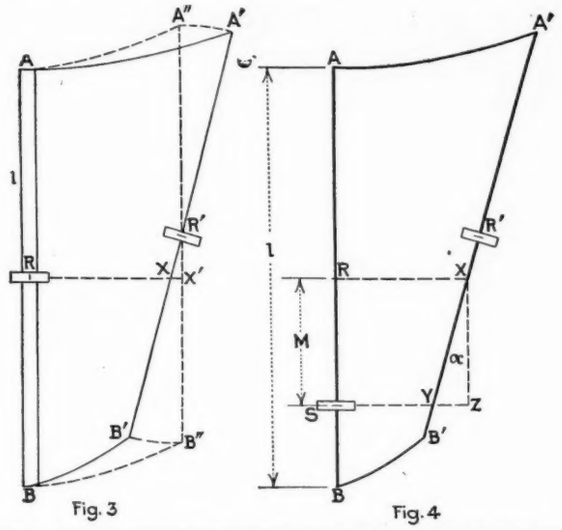
FIGS. 1 AND 2—MEASURING AREA COVERED BY MOVING BAR

In Fig. 1 we have a rod AB with its center at R. If this rod be moved sidewise into a new position $A'B'$, the end A will describe the path AA', while B will describe the path BB', and the center R will have traveled along RR'. The figure made by the movement of the rod is $AA'B'B$, whose area is equal to $AB \times RX'$ where RX' is the distance between AB and $A'B'$. RX' is likewise the component of the path RR' of the point R that is at right angles to the rod AB.

If a wheel were placed at R, as in Fig 2, with a mark on the rim, then the distance RX' would be the amount of travel registered by the index mark on the rim. If the rod were moved to the position XY, the wheel would trace the line RX'. Then if the rod were moved lengthwise from its position to $A'B'$, this lengthwise travel would have no effect on the wheel, since the latter would merely slide without turning. We see that the area covered by the travel of the rod is equal to the rod length times the travel of the wheel at the rod center.

The same reasoning applies if, as in Fig. 3, the lower end of the rod in moving from B to B' travels a

shorter distance than A in going from A to A'. The area $AA'B'B$ here is equal to AB, which will be called l, times the wheel travel RX' for the position $A'B'$ could have been reached by moving the rod to the position $A''B''$, whereupon, as shown, the area $AA''B''B$ would be equal to $l \times R'X$ and then when the rod was twisted



FIGS. 3 AND 4—RESULT WHEN ONE END OF BAR TRAVELS FARTHER THAN THE OTHER END

to bring it into the position $A'B'$, the wheel would have merely served as a pivot without rotation. It may be stated that for any movement of the rod AB the figure outlined by the movement is equal to the rod length l times the wheel travel RX or ld.

If the wheel be placed at some point S instead of at the center as in Fig. 4 and if M be the distance between the rod center R and the wheel S, the wheel reading will be SY, which is equal to RX — the distance YZ. This distance YZ is equal to M sine α when the angle $\alpha = ZXY$.

The area of the figure $AA'B'B$ is then $l\,(SY + M$ sine $\alpha)$. If the rod be moved to, say, the points CD as in Fig. 5, the area is still the rod length times the sum of the wheel travel and M sine α or $l\,(d + M$ sine $\alpha)$ where d is the wheel reading.

If the rod be returned over the same path as in Fig. 5 to the position AB, the scale reading becomes zero and the area disappears. Suppose, now, that instead of moving the rod back over the same path A takes the path ACI and B the path BDF, as shown in Fig. 6; the wheel reading will be zero, and the going and returning areas will cancel each other.

If, on the other hand, the point B were constrained

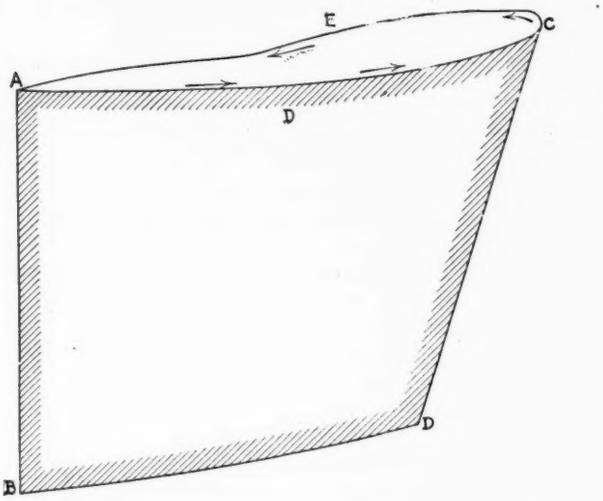
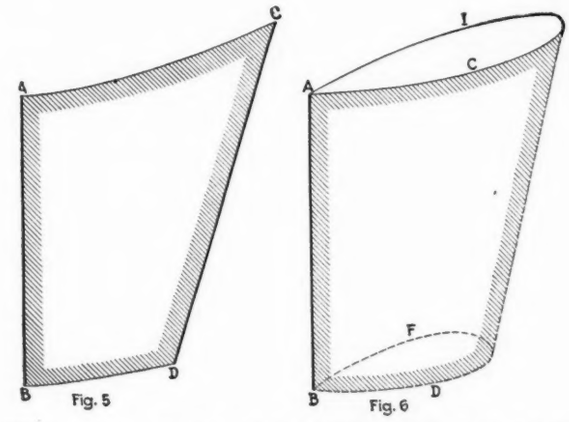


FIG. 7—ONE END OF BAR RETURNS ALONG NEW PATH

to follow the path BB both going and returning, while the point A was free to have a different path of return, the figure would be as in Fig. 7. The area cross-hatched is eliminated by the return leaving a net area $ADCE$. The area of the entire figure, as shown before, is $l\,(d + M$ sine $\alpha)$ but since the total angle α becomes zero, we have the area equal to ldR or the net area $ADCE$ is equal to the wheel reading times the length of the rod AB.

This is the principle of the Amsler planimeter, Fig 8, when the point moves freely along the diagram while



FIGS. 5 AND 6—EFFECT OF RETURNING BAR TO ITS ORIGINAL POSITION

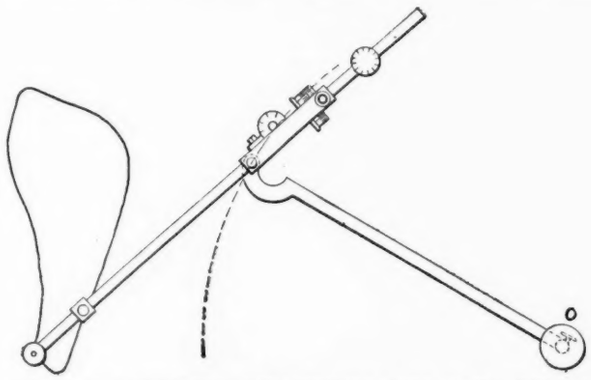


FIG. 8—PLANIMETER MEASURING THE AREA OF AN INDICATOR DIAGRAM

the hinge is constrained to move in a path along an arc with O as a center. The wheel is fastened beyond the point B, here the hinge, but the position of the wheel has no influence on the method of measuring areas.

DATA RELATING TO STANDARD MAKES OF UNIT HEATERS

Heater	Cu.Ft. of Air per Min.	Steam Pressure Lb. Gage	Initial Air Temp., Deg.	Final Air Temp., Deg.	B.t.u. per Hour
A	2,000	5	60	130	121,000
B	15,000	5	65	115	749,000
C	2,070	100	60	167	236,000

Accurate Methods of Aligning Steam Turbines—Using Sound To Increase Sensitiveness of Measurements

BY EDGAR G. BARKER, SR.
Steam Turbine Superintendent, Beech Bottom Power Company

Reliability of machinery depends to a great extent on correct aligment. Precautions that may involve additional effort in order to secure great precision, often pay for themselves many times over. Mr. Barker, in a previous article, described special means of measuring sag in a tight line. The method here outlined for increasing the accuracy of micrometer measurements can be easily applied. By making accurate measurements easy to secure, the work of checking alignment may be greatly accelerated and made more dependable.

THE use of a tight line for aligning machinery, together with a special method of measuring or eliminating the sag when the line is used horizontally were described by the author in the Sept. 4 issue of *Power*. After the tight line has been stretched ready for alignment comes the question of micrometer measurements for locating the horizontal and vertical positions of the bearing pedestals, wheel casing, cylinder, generator or other pieces to be aligned.

Electric bells or buzzers have long been applied for indicating when a micrometer comes in contact with a metallic tight line. This is occasionally an aid to the erecting man, although sometimes considered in the light of an inconvenience. Fig. 1 indicates one plan of electrical connection for using such a method, in which a pair of telephone receivers is arranged for transmitting sound to the operator. When a contact is made with the tight line, a click is heard in the receiver. The tight line, in this case, is grounded, while the micrometer is insulated by a piece of fishpaper or similar material, from the pedestal or other element. The micrometer is ordinarily held against the insulation and when a contact is made with the wire, the battery circuit is completed to the ground through the telephone receivers, producing a clicking noise.

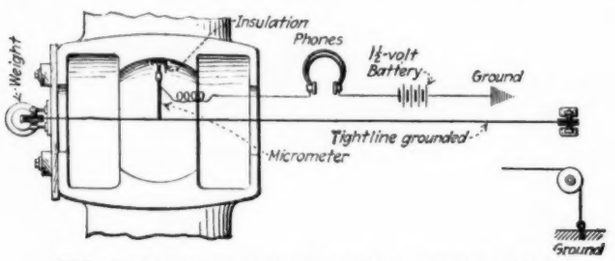


FIG. 1—SOUND INDICATES CONTACT ONLY OF MICROMETER AND TIGHTLINE

An improvement that has been devised in this method is indicated in Fig 2, where sound is not only used to indicate contact with the tight line, but also to determine whether the contact is of heavy pressure or light pressure. By this means, the variation in sound heard in the telephone receivers indicates whether the micrometer presses heavily or lightly against the tight line. Under proper conditions one may distinguish measurements with an accuracy of 0.0001 in.

The connections for using sound to indicate the accuracy of measurements are shown in Fig. 2. An electric buzzer is used in addition to the material required in Fig. 1, but in the latter case the tight line is insulated from the ground, instead of being grounded, as in the former.

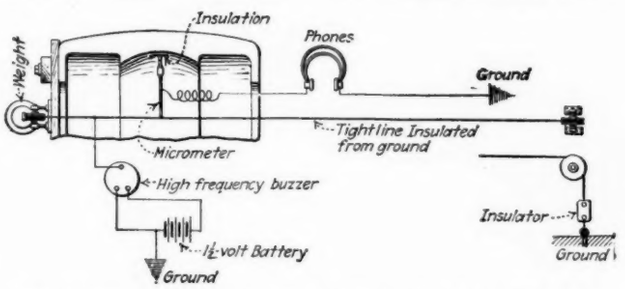


FIG. 2—SOUND VARIATION INCREASES SENSITIVENESS OF MICROMETER MEASUREMENTS

The battery is grounded at one side and connected from the terminals of a high-frequency buzzer containing an adjustable armature. The buzzer is also connected through a wire to the tight line. The telephone receivers are grounded at one end and connected to an insulated micrometer at the other.

When the micrometer contacts with the tight line, the headpiece receiver set is thus attached to the ground and an electric current is shunted through the receivers. If the wire that connects the buzzer to the tight line is connected to the grounded terminal of the buzzer and a very low resistance receiver set is used, a faint sound will be heard in the receiver set. This may be varied by changing the adjustment of the armature. It may also be made louder by placing a resistance, such as an electric light in the wire connecting the grounded terminal of the buzzer and battery. This should be connected indirectly at the buzzer terminal.

If it is desired to make greater sound in the telephone headpiece, in case a higher-resistance set is used, the wire to the tight line may be connected to the terminal of the buzzer that goes directly to the battery, without ground, as at the right of the buzzer in Fig. 2. In this case the full voltage of the battery would act through the receiver and in all probability make too loud a noise, depending of course on the resistance of the receiver set capacity of the battery, etc. The sound may be varied by changing the adjustment of the buzzer armature or placing resistances in the various paths of the current.

The sound may also be changed by connecting the wires to the tight line at a point inside of the buzzer, such as between two magnets, in case there are two in the buzzer used. This would be expected to give a sound intermediate between the first and second positions, as described. It is necessary, as a rule, to do a little experimenting at first in order to find the amount of sound that is most suitable to the operator.

When a measurement is taken, the micrometer is held against the stationary element and adjusted so as to contact with the tight line. A heavy or light touch on the tight line will make a considerable difference in the

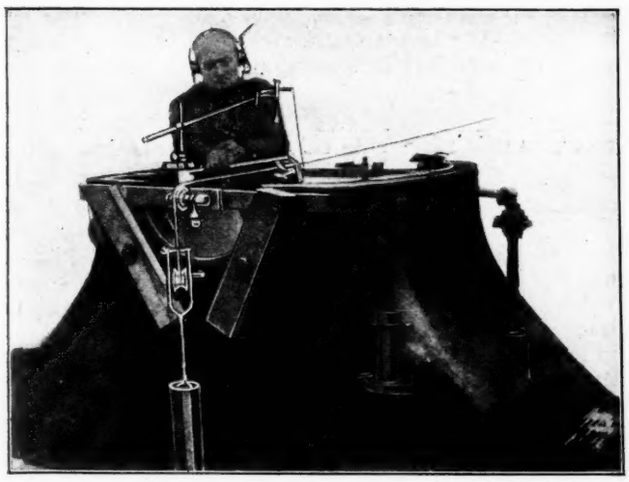


FIG. 3—ELIMINATING SAG AND MEASURING BY SOUND VARIATION

phone-receiver noise, so that the actual measurement can be made much more quickly and accurately than if the sense of touch alone were used.

After the bearings and other parts of a turbine have been correctly aligned in regard to a central axis, allowances must be made for turbine expansion due to both steam and exhaust temperatures, expansion of bearing pedestals, generator and other elements of the machine. These matters vary with different types of units and should be properly taken into consideration. The bearing pedestals and other supports must therefore be shimmed up or down in accordance with the changes that take place between the cold and the operating conditions of the machine. Fig. 3 shows the apparatus being applied.

Factors That Influence Stopping an Elevator

By William Zepernick

The ability of a brake to stop an elevator is determined first by the character of the brake lining, which will have a definite coefficient of friction when in contact with the brake wheel. This will vary with the speed. The coefficient of friction between two surfaces is a value which, when multiplied by the total pressure between the two surfaces, obtains the frictional drag (expressed in pounds) exerted. The second factor, then, in the braking action is the total pressure exerted by the brake springs, and the third is the distance through which the brake acts for a given distance of car travel when stopping. This last factor is determined by the diameter of the brake wheel and the gear reduction of the elevator machine.

It can thus be seen that the contact areas of the brake shoes have theoretically no bearing on the braking action with respect to the dimensions of force and distance as already outlined. Certain consideration, however, must be given to the contact area, for upon this surface depends the distribution of wear and the ability to radiate heat developed in stopping. Another consideration is the percentage of change in braking action caused by foreign substance on the contact area.

Increasing the area of contact of the brake shoes will aid in stopping the elevator more quickly when the face of the brake wheel is also extended to provide more radiating surface to permit the brake to operate at a lesser temperature, as the temperature has also a distinct bearing on the coefficient of friction. After the contact surface has been increased to a size compatible with good service, further increase will have but little effect. Neglecting friction of the machine bearings and guide shoes of elevator carriage and counterweight, the static friction of the brake linings upon the brake wheel, multiplied by the gear reduction and the radius of the brake wheel, must be at least equal to the product of the unbalanced load and the radius of the driving sheave or drum in order to hold the elevator at rest. With some types of elevator machines the gear reduction is such that the elevator will stand at rest without the aid of the brake.

The work done by the brake in stopping an elevator is a measure of the weight in motion and square of the velocity at which it travels. This applies to every portion of the equipment in motion in direct mechanical connection with the elevator machine. When the elevator must be stopped from high speed by the brake only, the work involved is great, as the masses in motion will aggregate a weight seldom under 6,000 lb. The greatest determining factor is the speed at which the mass is in motion, as the energy contained is proportional to the square of the speed at which it travels. Of course each portion of the equipment must be considered separately if moving at different rates of speed; for instance, the speed of the car and the counterweight may be the same if the roping is such as to permit, and these two may then be considered as a unit. The motor, however, revolving about a center must be considered separately. As all portions of the armature do not travel at the same rate of speed, an equivalent speed or weight must be used. That portion of the equipment which obtains the greatest product of weight and velocity squared requires the greatest portion of brake action to bring it to rest. With geared-type machines the motor armature requires the greatest effort from the brake when stopping. When stopping, the energy contained in the moving equipment due to its motion is dissipated by the brake shoes and wheel in the form of heat. When relying only upon the brake for stopping, higher speeds for elevator travel could not be realized, as the difficulties presented by the conditions of stopping could not be surmounted practically. With alternating current, where dynamic stopping could not be obtained, progress was impeded until the development of the two-speed alternating-current motor. This permits the brake to be relieved of a great part of the work necessary to stop the equipment, since from high to slow speed the machine is slowed down by the dynamic braking action of the motor.

Centralized Control of Steam-Heating System Based on Outside Temperature

SINCE a steam-heating system must be designed for sufficient capacity to suit the coldest weather, it follows that when the outside temperature is somewhat higher and less heat is actually needed, the radiators must be operated either at a reduced temperature or heating surface or for shorter periods of time, in order to furnish the same internal building temperature. Radiators may be individually adjusted to meet the heating requirements by hand, semi-automatically or by automatic control. The first two methods subject the radiators to possible neglect and the latter to errors of the regulating devices. In all three instances a considerable amount of heat may be wasted by the occupants of the rooms opening the windows wide, in order to lower the temperature, while the radiators supply an abnormal amount of heat in proportion to the outside temperature.

THE heat radiated by a building varies almost directly as the difference between the constant temperature maintained within and that of the outside atmosphere, other conditions being equal. Heating steam supplied in practice has been found to exceed greatly this proportion for smaller ranges of temperature difference. By controlling the steam from a central point according to outside temperature, radiators may be operated at a reduced rate exactly suited to requirements. Waste due to abnormally high radiation and consequent opening of windows is thus avoided. The active heating surface is reduced rather than the temperature of the entire radiator, representing greater efficiency than that of the latter method with individual control.

The heat required by a building is ordinarily considered to vary in almost direct proportion to the number of degrees it must be heated above the outside temperature. Tests indicate that the heat actually used for maintaining the internal temperature of a building is much above the calculated value when a comparatively small heating range is required. The tests of a building supplied with steam at practically constant pressures and temperature are shown in Table I. With zero outside temperature and 70 deg. internal temperature, the steam utilized corresponded to that calculated for the building. As the outside temperature increased, however, the steam supplied to the heating system was much greater in proportion than that indicated by calculation. For 60 deg. outside temperature, which represented 10 deg. of heating, 750 lb. of steam per hour would be calculated as necessary, while 3,250 actually was furnished. In this case the steam actually required was about 400 per cent of what should be supplied.

In order to cut down the waste of heat, the Donnelly Distributed Heat System has been devised, which controls the entire supply from one central point in accordance with outside temperature and heats at nearly constant temperature. The steam supplied is then distributed mechanically to all the radiators, so that heating will be furnished in accordance with specified conditions. Steam entering the radiators is varied in amount rather than pressure. Heating therefore occurs at practically constant temperature and variable heating surface. This is more convenient than a system of constant surface and variable temperature.

A two-pipe heating system of this character is indicated in Fig. 1. The main header contains an orifice which acts as a flow meter in connection with gages, for the purpose of measuring the steam distributed to the system. A reducing valve regulates the steam pressure supplied as desired. Provision is made for a hand-regulated bypass indicated above, which also contains a similar flow meter. Typical main and riser orifices appear in Fig. 4. Orifices may be equipped with soft gasket surfaces.

A curve may be plotted between the pounds of steam per hour required for heating purposes and the gage pressure of the steam admitted to the flow meter. The drop on the discharge side of the orifice may be neglected, as this represents only a few ounces due to the drop in the piping, while the pressure on the other side is several pounds, rising over 25, in Fig. 3. A curve is plotted between the steam per hour as required and the pressure in pounds at the flow meter. This represents 70 heating degrees Farenheit where the building is maintained at 70 deg. inside while the outside temperature is zero. The figures of the lower part of the curve, Fig. 3, may read in degrees of outside temperature as well as pounds of steam per hour. If there are wind conditions that change the heating requirements on different sides of the building, it is possible to use two main distributing systems, one of which will take care of that part of the building most affected by high winds in cold weather.

The curve including the part from 0 to A is calculated from the formula $W = 400\ AC\sqrt{p}$; the curve from A to B by the formula $W = 50\ AC\ P$, where W equals the weight of steam in pounds per hour, A the area in square inches, C the co-efficient of the orifice, p the gage pressure and P the absolute pressure lb. per sq.in., at high side of orifice. In computing this curve, A is taken as one square inch and C is assumed as 1.

The first formula is developed from Rankine's, in which the lower pressure is 58 per cent of, or more than the initial pressure. The second formula is developed from Napier's, which represents the flow through the orifice where the low pressure side is 58 per cent or less than 58 per cent of the pressure of the high side; in other words, the Rankine formula applies below the critical point A of the pressure, and Napier's above the critical point, the delivery pressure being atmosphere in each case.

The pressure in the steam main and risers may be calculated from the formula $P = K \left(\frac{70\text{-}t}{70}\right)^2$, where P equals the pressure drop, t the temperature in degrees

Fahrenheit and *K* the pressure at maximum flow, which is four ounces for the main and one ounce for the risers. The tabulations are indicated in Table 2. In the lower part of Fig. 3 is plotted the outside temperature in degrees Fahrenheit and the resulting pressure in ounces in the main and in the risers.

The distribution of the steam is controlled by means

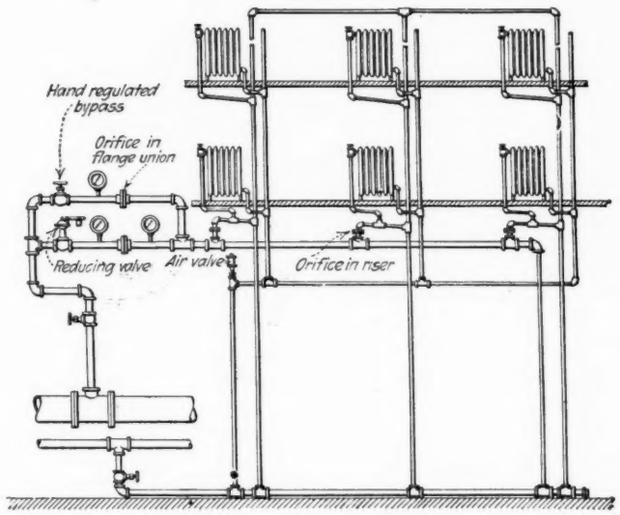


FIG. 1—STEAM SUPPLIED TO A HEATING SYSTEM IS REGULATED AT ONE CENTRAL POINT

of orifices in the riser connections. Risers in all cases are taken to the tops of the buildings and there connected together in groups by equalizing pipes for the purpose of making noiseless circulation. The air valves were removed from the radiators and placed on the return pipes, Fig. 1, so that this represents a return air

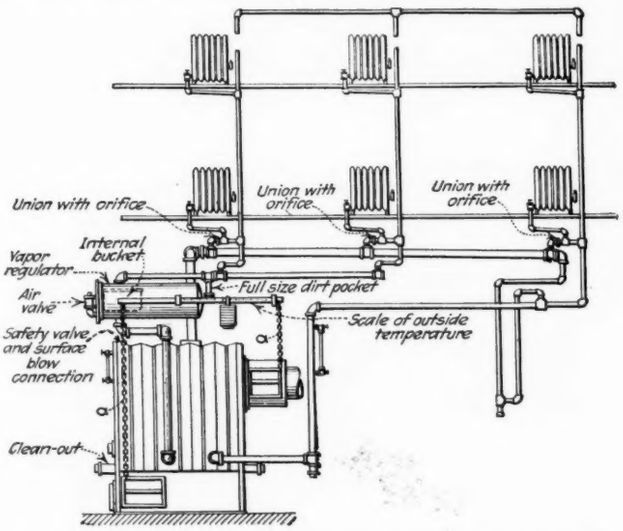


FIG. 2—AUTOMATIC REGULATOR ADJUSTS THE STEAM GENERATED TO SUIT OUTSIDE CONDITIONS

system, doing away with the trouble from air valves on the radiators. Fractional distribution valves were placed on each radiator for permanently adjusting its supply of steam.

The distribution system comprises a large number of risers in preference to extensive horizontal connecting pipes. The vertical distribution of steam is much simpler than that in a horizontal direction. The difference in weight between the column of steam and air is such that it nearly offsets the friction of flow for the average fractional load. Therefore the orifice in the fractional distribution valve at each regulator is adjusted in direct proportion to the amount of radiating surface, regardless of the varying vertical distance from the base of the riser. The total area of steam mains

TABLE I—STEAM REQUIRED AND THAT ACTUALLY CONSUMED IN HEATING A BUILDING

Deg. F. Outside Temperature	Pounds of Steam per Hour: Calculated Requirement	Pounds of Steam per Hour: Actually Consumed
0	5,150	5,150
10	4,450	4,700
20	3,650	4,200
30	2,950	3,800
40	2,200	3,500
50	1,470	3,450
60	750	3,250

TABLE II—CALCULATED RISER PRESSURES AND PRESSURE AT FLOW-METER GAGE CORRESPONDING TO OUTSIDE TEMPERATURE

Outside Temperature	Pressure in Lb. Sq.In. at Flow Meter	Pressure In Oz. Sq. In. Main	Pressure in Oz. Sq.In. in Riser
0	27.3	4.0	1.0
10	21.3	2.9	0.73
20	15.3	2.0	0.51
30	9.0	1.3	0.33
40	5.07	0.73	0.18
50	2.25	0.33	0.08
60	0.563	0.08	0.02

leaving the boiler should be such that a maximum velocity of 16 ft. per sec. is not exceeded.

If one part of the building is apparently unduly affected by wind conditions, a separate steam header with its own system of risers and flow meter corresponding may be used for special regulation for severe weather.

In Fig. 2 is shown a system of heating wherein the pressure generated by the boiler is regulated in accord-

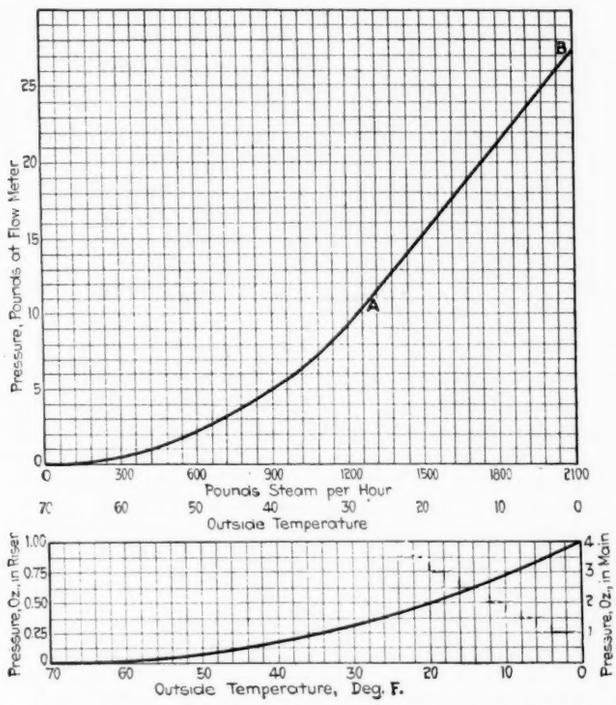


FIG. 3—PRESSURES AT THE FLOW METER FOR VARIOUS OUTSIDE TEMPERATURES

ance with outside temperature. In this case a separate device operating against a weighted scale beam measures the amount of return condensed water from part of the system, or if preferred, from the entire system. The weighted scale beam operates the damper and drafts of the furnace so as to maintain the condensation per minute at the rate necessary to suit outside temperature conditions. The weight on the scale beam may be moved

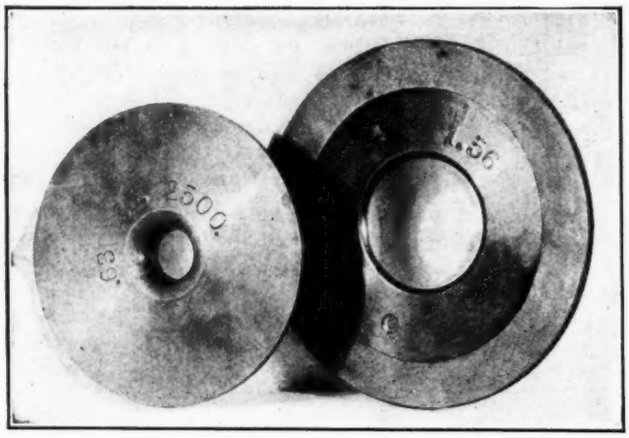


FIG. 4—GASKET BUILT INTO LARGER ORIFICE

out in accordance with outside temperature, so that the correct amount of steam will thereby be furnished. The actual measuring device consists of a bucket provided with a hole near the bottom. This is contained in a tank and receives water from the entire heating-system returns or part of the heating-system returns. The more water that is returned the higher will be the level maintained in the bucket due to the opening in the side near the bottom. This water is automatically weighed by the scale beams so that it tends to operate the scale beam and close the damper when more than the required condensation is being used.

A Crankless Air Compressor

Numerous attempts, more or less successful, have been made to eliminate the heavy parts of an engine or compressor required to translate the reciprocating to circular motion. Among these new designs the crankless engine, wherein the pressure exerted on the piston is transferred to a plate set at an angle with the cylinder axis, has been exploited. In the majority of such engines the frictional resistance offered by the plate to the sliding of the piston shoe has been so excessive as to limit the success of the machine.

A. G. M. Michell is well known as the designer of the Michell thrust bearing largely used on board ship to take the propellor thrust. The chief merit of this bearing is its low frictional resistance, which is due to the maintenance of an oil film between the two rubbing surfaces. Mr. Michell has made use of this bearing in a crankless engine manufactured by the Crankless Engine Proprietary, Limited, of Melbourne, Australia, which is being introduced in the United States. The engine is adaptable, with modification in the valve gear to use as an air compressor, unaflow steam engine, gas engine, etc. The air compressor is especially interesting since, by reason of the excellent balance of the machine, it can be direct connected to high-speed electric motors; this reduces the total cost for a given output over the cost of a slow-speed machine an appreciable amount.

In Fig. 1 is shown a cross-section of an 8-cylinder compressor, while Fig. 2 shows it direct connected to a motor and equipped with water-circulation pump, etc.

The machine shown is of the standard crankless 8-cylinder type with the standard angle of slant of 22½ deg. and is split on the horizontal plane for facility of assemblage. The valves are of rotary type positively driven by a flexible drive from the shaft, being mounted independently of the shaft on spigot extensions from the end covers, upon which they revolve without making contact with either the shaft or the internal face of the valve chamber. To insure maintenance of the proper clearance in the valves and of the true form of the machine in other respects, the main castings and valve castings are carefully annealed after being rough-machined.

The essential features of the slant are that its face shall be truly plane and parallel, that it shall be statically balanced about the axis of the shaft and that its geometrical form be such that its principal product of inertia can be accurately calculated. The pistons are

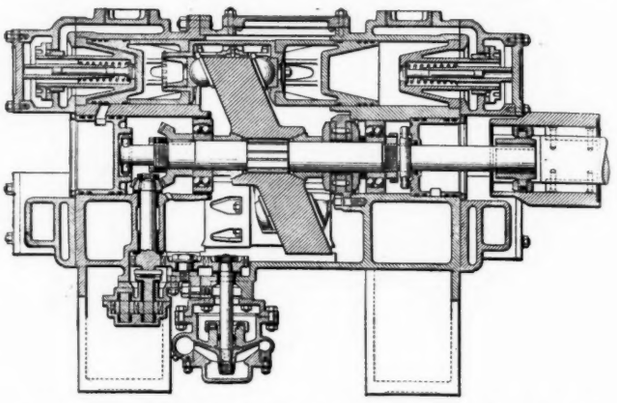


FIG. 1—CROSS-SECTION OF CRANKLESS COMPRESSOR

dynamically balanced to the extent of approximately 75 per cent by the slant, the remaining balance being effected by weights in the coupling and pulley at opposite ends of the machine.

The cylinders are bored parallel to the shaft and the slipper-cups are concentric with the pistons, so that the line joining the centers of the slipper-balls is parallel to the shaft.

It will be noticed that the thrust of the mainshaft is carried on collars integral with the main-journal bearings, packing rings being inserted between these collars and the main castings of the machine to allow adjustment of the end clearance should wear of the thrust collars take place. In machines of this type all end thrusts are automatically balanced.

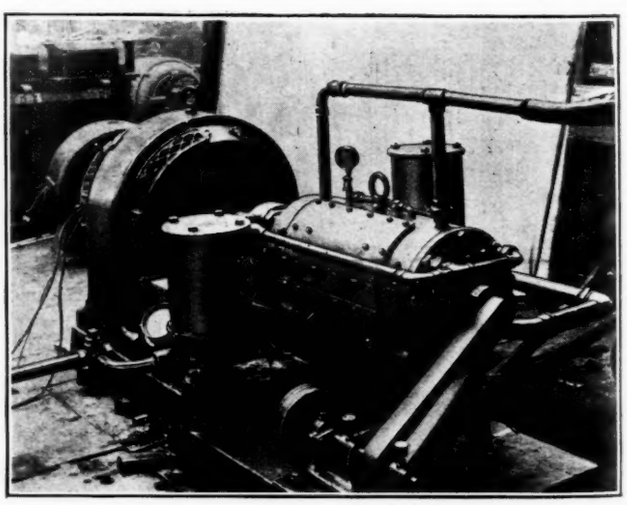


FIG. 2—COMPRESSOR DIRECT CONNECTED TO MOTOR

Furnace Setting for Oil-Fired Boilers

By George C. Adams

The increasing use of oil as a boiler fuel renders more important than ever the question of efficiently burning the oil in the furnace. The furnace must be designed with the following two important points in mind: (1) The lessening of losses by decreasing the excess air entering the furnace; (2) the distribution of the fire evenly over the entire surface of the firebox.

The first of the above points is well understood by all. The best index to the losses going up the stack due to excess air is an analysis of the flue gases with an ordinary Orsat apparatus. With regard to the second it may be said that not only does an even distribution of the fire result in a saving due to lower stack temperatures, but the efficiency of the boiler itself is improved. A concentrated flame causes heavy deposits of scale on the portions of the boiler exposed to the direct action of the flame, thus impairing its evaporation capacity and adding to the danger and inconvenience of burnt tubes. Moreover, a hot flame projected with any appreciable velocity against the brickwork has a destructive action, causing the bricks to erode rapidly.

The excess air entering the furnace can obviously never be cut down to zero. While too much air represents a loss, too little air will cause the fires to smoke and increase the carbon monoxide in the flue gases. The presence of this gas represents a loss just as serious as that due to excess air. The problem is, then, to introduce just as little air into the furnace as will completely consume all of the fuel.

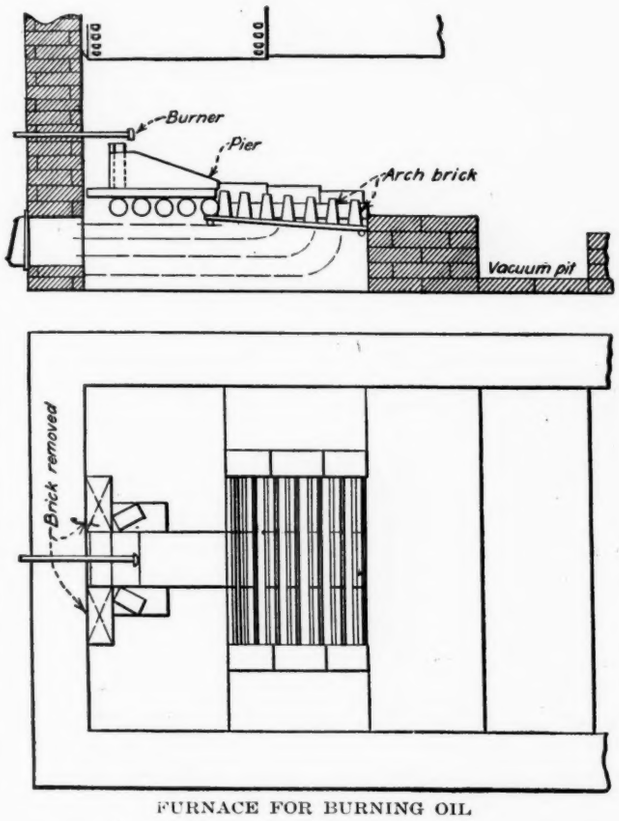
The presence of only a small amount of excess air and no carbon monoxide means that the air that does come into the combustion chamber must be thoroughly mixed with the burning gases. The best way to get a thorough mix is to have the flame surface as large as possible. Obviously, the larger the flame surface for a given amount of burning fuel the greater the chance of the air to get into intimate contact with the burning gases. Furthermore, if the flame can be caused to roll along the firebox, from the front to rear, thus tending to envelop the air in the combustion chamber, the greater will be the chance for a thorough mix. It is seen that not only does distribution save directly some of the heat that otherwise would escape, but also it enables the excess air to be cut down.

The flame produced by ordinary equipment is very hot and concentrated and has a tendency to cling together. It is projected along the furnace with high velocity, hitting the walls near the back, producing hot spots that give the wall a tendency to warp. Moreover, the action of a hot flame of this sort on the bricks is analogous to a stream of water and will cause them to become worn in a short time.

If the design of the combustion space could be altered to accomplish the desired result, a gain in efficiency could be reasonably expected. It was with these factors in mind that the furnace shown in the illustration was devised. The results obtained by its use more than verified the ideas mentioned. Tests not only showed an increase in the carbon-dioxide content of the flue gases, but gave an increase in efficiency greater than could be accounted for by the cutting down of the excess air.

The furnace is really composed of two important parts, the air spacing and the vacuum pit. The air spacing is about half the width of the firebox and roughly rectangular in shape. It is composed of standard arch bricks set on the large side and spaced as shown. The whole affair is supported by a number of ½-in. pipes having a slight downward slope toward the furnace front, the pipes in turn being supported by 2-in. pipes extending entirely across the firebox. These larger pipes also hold up the front and the sides of the furnace. There is one row of bricks on each side of the arch bricks, these bricks being placed so as to be above the air spacing bricks.

The purpose of the air-spacing bricks is as follows: All the air that enters the furnace must enter through the damper into the space under the furnace proper. This air, in order to get into the combustion space,



FURNACE FOR BURNING OIL

must proceed in the direction shown by the dotted arrows. In passing through the air spacing, it is caused to enter at right angles to the direction of propagation of the flame. This breaks up the stream of burning oil, giving the flame a tendency to roll, thus insuring a thorough mix. These bricks also serve another useful purpose. In the course of the firing operation they become exceedingly hot across the top faces and the entering air is in some measure preheated before coming in contact with the burning fuel.

The flame, after passing the air-spacing bricks, has a tendency to roll outward, thus filling the firebox in its entire width. Upon passing over the vacuum pit, the flame is dispersed upward, thus entirely filling the combustion chamber with burning oil. This rolling action causes the air present to be thoroughly mixed with the burning gases, insuring complete combustion with a minimum of excess. The entire inside of the firebox is also brought to nearly the same temperature and the

wear on the brickwork is minimized. The even temperature presents the advantage that the setting will hold the heat for a much longer period during a shutdown.

It was found by experiment that the efficiency of the device could be improved by allowing a small amount of air to come in contact with the fuel where it was ejected from the burner. In order to accomplish this, two bricks were left out of the front of the setting as shown in the sketch. This allows a small portion of the air entering through the damper to proceed directly upward to the end of the burner. The two bricks placed on edge on top of the pier in the manner shown, insure passage of the entering air to the upper point.

An Electrical CO Meter

A recent development of the Bacharach Industrial Instrument Co., Pittsburgh, Pa., is an electrical CO indicator. The operation of the meter is based on the catalytic action of a heated platinum wire in producing combustion of CO with oxygen. Referring to Fig. 1, *A* and *B* are two small platinum wires, each passing through the center of cylindrical chambers in two separate metal blocks. *B* is the comparison wire and *A* the measuring wire in the chamber through which the sample of flue gas passes slowly. The wires are heated to a temperature of about 800 deg. F. by an electric current. Usually, enough oxygen is present in the waste gases for the combustion of the CO and hydrogen, but to make certain of this, air to the amount of 20 per cent of the gas volume is admitted through the small passage *E*, Fig. 2. The catalytic action causes the CO and H_2 to burn along the surface of the wire *A*, thereby raising its temperature and increasing its resistance in almost direct proportion to the amount of these gases present. When considerable amounts of CO are present, the wire is heated to a brilliant glow. As *B* maintains constant temperature and resistance, the Wheatstone bridge circuit, consisting of the wires *A* and *B* and the resistances *C* and *D*, becomes unbalanced, causing an indication on the galvanometers *F* and *H*. These instruments are calibrated in percentage of CO or CO plus H_2. As the combustion heat of a given volume of H_2 is almost identical with that of CO, the CO meter may serve for a mixture containing both gases. For boiler-house practice it is not necessary to know what part of the sum is CO and what part is H_2; the important thing is the indication that these combustibles are present and to what extent combustion is incomplete. Methane or other hydrocarbons are not indicated, but they occur only in small quantities except where the CO content is very high.

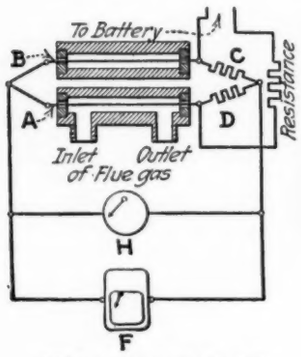


FIG. 1—DIAGRAM OF TESTER AND METERS

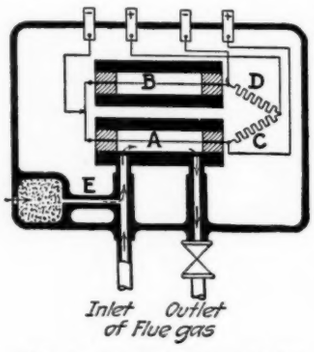


FIG. 2—SECTION THROUGH CO TESTER

The catalytic effect is dependent to some extent on the velocity with which the gas flows past wire *A*. As the electrical CO meter is mostly used in addition to an electric CO_2 meter described in a previous article (page 417, Sept. 11 issue), the rate of gas flow in the CO meter is chosen to be the same as that through the CO_2 meter. Changes of as much as 100 per cent in this rate of flow have practically no influence. The effect of difference in heat conductivity due to CO_2 is present in the CO meter just as in the CO_2 meter; this effect in the CO meter is overbalanced by the catalytic action, so that the highest percentage of CO_2 possible in boiler waste gases has less influence than per cent of CO.

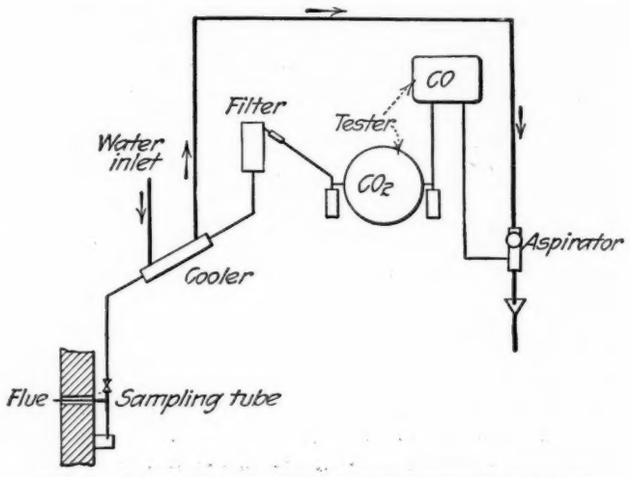


FIG. 3—DIAGRAM OF PIPING CONNECTIONS FOR CO_2 AND CO METERS

The arrangement of a CO meter with accessories, and combined with a CO_2 meter, is shown in Fig. 3. The gas sample is drawn in continuously by an aspirator through a cooler around which circulates the water going to the aspirator. From the cooler the gas passes through the filter to the throttle disk and to the CO_2 meter, which is equipped with a small control filter and a manometer for checking the velocity of the gas sample; thence to the CO meter and the aspirator.

The CO meter requires across its terminals a voltage of 2.7, and the current passing through the Wheatstone bridge amounts at this voltage to 0.85 ampere. To supply this current, a storage battery may be used or the meter may be connected to a direct-current line of 120 or 240 volts. In either case a resistance of suitable amount must be provided in series with the CO meter to keep the current within the limit of 0.85 ampere.

In a new pump that handles water reasonably free from air, the slip rarely exceeds 2 per cent of the piston displacement when the pump is operated at normal capacity, and in packed pumps, where there is no leakage past the plunger or piston, the percentage of slip is less. Frequently, pumps handling large quantities of water have shown slips of ½ per cent, no slip, or negative slip; that is, the delivery of water has been in excess of the piston displacement from the tendency of the water to flow after the plunger has stopped. With large pumps it is difficult to determine the slip accurately as there is no absolutely reliable method of measuring large flows of water, and the error of measurement is likely to be more than the slip in a pump in good condition.

Power Utilized in Michigan's Industries

ALTHOUGH Michigan contains much natural water power, this is utilized to an appreciable extent only in the industrial groups representing paper and pulp and also in the manufacture of iron and steel and products. Steam engines represent the largest class of prime-mover capacity in the private plants, although steam turbines predominate in several industrial groups.

THE STATE of Michigan is perhaps popularly associated with the manufacture of automobiles, as representing its greatest activity. In respect to installed driving capacity and electrical power required, the industrial survey for 1920, by *Power* and *Electrical World*, does not rank this group in the highest position. Industrial activity appears to have been influenced more strongly by the natural resources of the state and their exploitation than by manufacturing as ordinarily visualized. The industries grouped under (1) stone clay and products, including the manufacture of cement, (2) paper and pulp, and (3) total mining occupy the first three positions in regard to the electrical power utilized. The six leading industrial groups are represented in Fig. 2. It is noteworthy that the three largest generate the majority of the power used by them in their own private plants. The next three groups, and in fact the average of all, purchase more power from public utilities than is generated by them electrically.

Michigan has abundant rainfall, which is naturally conserved by an absorbent, gravelly soil, as well as numerous lakes and forests. It contains many short rivers of even flow and comparatively low or medium

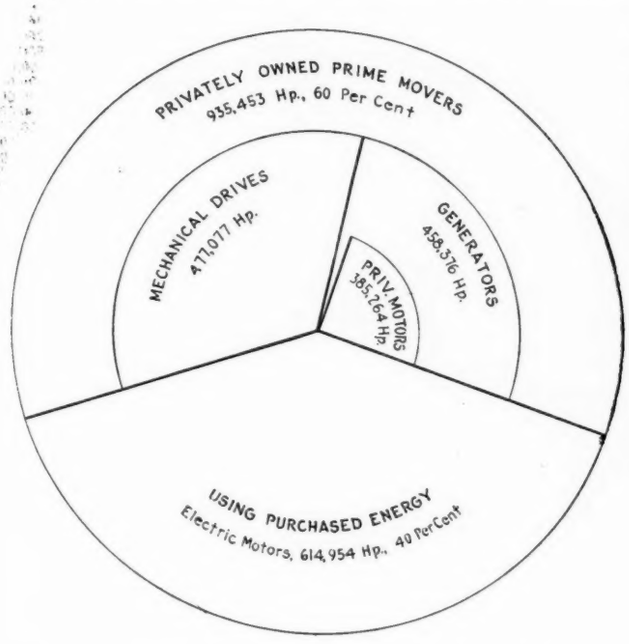


FIG. 1—MOTORS USING PURCHASED CURRENT EQUAL TWO-THIRDS OF PRIVATE PRIME-MOVER CAPACITY

hydraulic heads. Good use has been made of these as approximately three-fourths of the available water power was utilized in 1921, totaling over 250,000 hp.

The power survey indicates that waterwheels represent an almost insignificant proportion of private prime-mover horsepower. The total amount of water prime-mover horsepower is 48,000, approximately, according to this estimate, representing about one-fifth of the entire water-power development. Water power is principally represented in the paper and pulp, as well as the food and products groups of industries. In the former group water power constitutes 25 per cent and in the second group 13 per cent of installed prime-mover capacity.

The leading industrial groups, as disclosed by this survey, are closely allied with the natural resources of

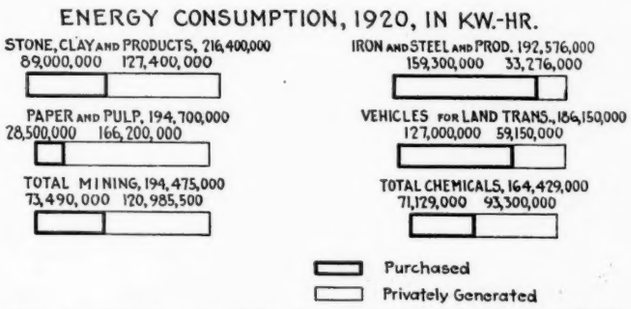


FIG. 2—THREE LEADING INDUSTRIAL GROUPS SUPPLY MAJORITY OF THEIR ELECTRICAL ENERGY

the state. Michigan is heavily covered with glacial drifts, bedrock being exposed in only about 10 per cent of the entire surface. The soil thus produced is largely sandy or gravelly in character, with about half of its area representing a clay soil. Thin and sandy soils in the north are not conducive to farming, where only a small part is in farms. Large areas of swamps and lakes also explain the retarded agricultural development. This, however, makes an excellent basis for the forests, from which the paper and pulp industry, as well as that of lumber and its products, are derived. Of the bedrock exposed in the north, in some instances copper and iron ores are included. The Lake Superior region is unique in being the only district from which a large output of native copper is derived. This occurs in lodes or masses varying in size from microscopic particles to bodies weighing hundreds of tons. Michigan ranked fourth in the production of copper in 1913 and second in iron ore.

In the central and southern parts of Michigan, limestone, coal and minerals representing a later geological period underlie the glacial drift, with occasional outcroppings. The fact that the total mining group stands first in prime-mover capacity, as in Fig. 3, while the industries represented by stone, clay and glass head the list in amount of purchased energy, Fig. 2, therefore, may be readily understood. Michigan ranks as one of the most important cement producing states. Clay products, such as brick, tile and sandstone are included.

Petroleum is practically absent, but the state contains a fair-sized deposit of lignite coal in the southern-central section. This has been comparatively little worked, on account of the utilization in the past of the waste from the lumber industry, for fuel. The coal-mining industry is a comparatively small one, as represented by the survey.

TABLE I—TOTAL PRIME MOVER EQUIPMENT FOR 1920 IN INDUSTRIAL PLANTS OF MICHIGAN

Industry	No. of Plants in State	Total Hp. of Prime-Movers in Industrial Plants	Steam Engines		Steam Turbines		Internal-Combustion Engines		Waterwheels		Estimate of Boilers in Industrial Plants	
			No.	Hp.	No.	Hp.	No.	Hp.	No.	Hp.	No.	Hp.
Agricultural implements	23	3,043	17	2,993	0	0	2	50	0	0	10	2,260
Chemicals and allied products (total)	358	92,558	379	47,117	64	43,419	32	1,922	1	100	282	80,980
Rubber and rubber products	7	6,525	8	2,025	3	4,500	0	0	0	0	24	6,350
Glass and glass products	25	125	1	125	0	0	0	0	0	0	1	110
Chemicals	197	67,628	139	29,516	45	37,387	6	625	1	100	173	55,000
Smelting and refining of metals	8	3,400	11	3,400	0	0	0	0	0	0	11	2,580
Artificial-gas manufacture	59	12,788	202	10,484	14	1,032	25	1,272	0	0	62	14,400
Miscellaneous chemical industries	62	2,092	18	1,567	2	500	1	25	0	0	11	2,540
Electrical equipment and machinery	54	302	1	265	0	0	1	37	0	0	1	150
Food and kindred products	2,251	72,900	440	54,074	24	6,184	14	2,873	248	9,769	206	61,600
Iron and steel and their products	848	48,639	160	33,054	28	12,311	9	1,690	2	1,584	179	49,000
Leather and its products	114	10,412	75	8,740	2	520	32	1,152	0	0	36	7,420
Lumber and its products	888	124,221	407	112,726	13	7,761	7	1,309	55	2,425	660	142,000
Metals and metal products other than iron or steel	462	19,683	92	17,497	2	1,415	20	546	4	225	64	14,680
Mining (total)	171	275,064	1,086	209,447	30	57,100	15	417	16	8,100	1,482	317,440
Bituminous coal mines	14	6,189	49	6,114	1	75	0	0	0	0	34	7,350
Copper mines	28	161,353	326	127,961	11	33,230	4	162	0	0	893	191,200
Iron-ore mines	100	94,778	655	69,497	13	17,132	4	49	16	8,100	485	104,000
Miscellaneous mines	29	12,744	56	5,875	5	6,663	7	206	0	0	70	14,890
Paper and pulp	60	90,706	168	57,637	13	10,050	0	0	66	23,019	222	64,000
Printing	1,315	5,052	25	4,472	1	46	10	519	1	15	17	4,860
Railroad-shop construction and repairs	51	3,926	25	3,633	1	260	1	33	0	0	16	3,430
Stone and clay and their products	391	45,251	268	26,734	26	15,600	38	917	14	2,000	97	25,800
Textiles	235	5,762	41	5,342	3	260	2	49	1	111	68	10,600
Tobacco	363	591	5	575	0	0	1	16	0	0	13	1,600
Vehicles for land transportation	586	106,272	298	38,266	57	59,177	214	8,784	1	45	487	129,200
Miscellaneous	517	31,071	.....	26,505	...	3,287	...	226	...	1,053	171	35,400
Totals for all manufacturing industries and mines in Michigan	8,687	935,453	3,487	649,077	264	217,390	398	20,540	409	48,446	4,011	950,420

TABLE II—ESTIMATE OF THE USE OF ELECTRICAL ENERGY BY INDUSTRIAL PLANTS IN MICHIGAN IN 1920 AND 1921

Industry	Electric Generators (In Private Plants) Direct-Current No.	Direct-Current Total Rating, Kw.	Alternating-Current No.	Alternating-Current Total Rating, Kva.	Electrical Energy Consumed: Purchased from Public Utilities 1920, Kw.-Hr.	Generated in Private Plants 1920, Kw.-Hr.	Total Energy Consumed 1920, Kw.-Hr.	Total Energy Consumed 1921, Kw.-Hr.
Agricultural implements	5	1,050	2	1,300	5,175,000	545,000	5,720,000	2,600,000
Chemicals and allied products (total)	31	5,200	67	27,710	71,129,000	93,300,000	164,429,000	118,054,000
Rubber and rubber products	4	570	4	3,260	3,905,000	11,300,000	15,205,000	11,130,000
Glass and glass products	0	0	0	0	384,000	0	384,000	254,000
Chemicals	15	3,360	58	21,900	60,800,000	71,000,000	131,800,000	91,800,000
Artificial-gas manufacture	11	1,220	4	2,440	2,700,000	10,540,000	13,240,000	13,240,000
Miscellaneous chemical industries	1	50	1	110	3,340,000	460,000	3,800,000	1,630,000
Electrical equipment and machinery	1	20	1	10	11,280,000	179,000	11,459,000	5,980,000
Food and kindred products	211	22,300	55	13,450	116,400,000	40,800,000	157,200,000	182,800,000
Iron and steel and their products	22	6,743	73	31,290	159,300,000	33,276,000	192,576,000	160,000,000
Leather and its products	41	3,700	15	13,800	4,950,000	9,600,000	14,550,000	8,360,000
Lumber and its products	30	7,630	49	12,700	12,800,000	8,600,000	21,400,000	16,200,000
Metals and metal products other than iron or steel	12	1,260	23	3,920	21,400,000	3,390,000	24,790,000	22,800,000
Mining (total)	193	30,960	38	23,030	73,490,000	120,985,000	194,475,000	130,100,000
Bituminous coal mines	12	1,870	2	1,390	960,000	7,290,000	8,250,000	6,400,000
Copper mines	96	15,400	15	11,430	8,830,000	60,100,000	68,930,000	29,800,000
Iron-ore mines	73	11,760	11	8,730	51,600,000	45,850,000	97,450,000	81,000,000
Miscellaneous mines	12	1,930	2	1,480	12,100,000	7,745,000	19,845,000	12,900,000
Paper and pulp	56	15,200	87	43,400	28,500,000	166,200,000	194,700,000	198,700,000
Printing	9	950	3	450	43,250,000	2,840,000	46,590,000	34,300,000
Railroad-shop construction and repairs	1	90	1	300	8,090,000	965,000	9,055,000	6,950,000
Stone and clay and their products	28	4,700	73	26,110	89,000,000	127,400,000	216,400,000	163,000,000
Textiles	16	1,550	8	770	3,495,000	1,324,000	4,819,000	4,050,000
Tobacco	2	280	1	140	800,000	638,000	1,438,000	1,400,000
Vehicles for land transportation	49	7,560	32	16,800	127,000,000	59,150,000	186,150,000	175,200,000
Miscellaneous	352	35,600	109	7,040	21,600,000	21,800,000	43,400,000	32,700,000
Totals for all manufacturing industries and mines in Michigan	1,059	143,793	629	222,210	798,159,000	690,992,000	1,489,151,000	1,263,194,000

TABLE III—ESTIMATE OF THE NUMBER AND RATING OF MOTORS INSTALLED IN THE INDUSTRIAL PLANTS OF MICHIGAN IN 1920

Industry	Motors Run by Purchased Energy Number	Motors Run by Purchased Energy Total Rating, Hp.	Motors Run by Energy Generated in Private Plants Number	Motors Run by Energy Generated in Private Plants Total Rating, Hp.	Total Motors in All Plants Number	Total Motors in All Plants Total Rating, Hp.	Distribution of Drives: Motors Under 5 Hp.	Belt, Number	Chain, Number	Directly Connected, Number
Agricultural implements	252	3,154	26	332	278	3,486	70	126	9	143
Chemicals and allied products (total)	1,381	24,341	2,143	33,232	3,524	57,573	935	1,627	647	1,250
Rubber and rubber products	107	2,227	308	6,435	415	8,662	126	244	25	146
Glass and glass products	16	176	0	0	16	176	5	9	1	6
Chemicals	1,152	20,135	1,643	23,511	2,795	43,646	714	1,184	608	1,003
Artificial-gas manufacture	47	805	184	3,149	231	3,954	70	151	9	71
Miscellaneous chemical industries	59	998	8	137	67	1,135	20	39	4	24
Electrical equipment and machinery	828	5,357	16	85	844	5,442	523	566	6	272
Food and kindred products	3,920	48,044	1,680	16,860	5,600	64,904	1,730	3,231	805	1,564
Iron and steel and their products	16,700	157,685	3,210	30,322	19,910	188,007	7,450	11,080	390	8,440
Leather and its products	262	3,418	509	6,619	771	10,037	215	678	35	58
Lumber and its products	2,083	22,088	1,400	14,859	3,483	36,947	1,058	2,593	29	861
Metals and metal products other than iron or steel	2,605	32,932	410	5,214	3,015	38,146	726	2,970	357	586
Mining (total)	1,022	66,159	1,739	109,960	2,761	176,119	952	757	102	1,902
Bituminous coal mines	10	695	179	5,285	189	5,980	66	40	2	147
Copper mines	261	8,236	888	56,088	1,149	64,324	398	305	44	800
Iron-ore mines	523	48,162	580	42,782	1,103	90,944	378	329	44	730
Miscellaneous mines	228	9,066	92	5,805	320	14,871	110	83	12	225
Paper and pulp	393	5,854	2,300	34,202	2,693	40,056	1,134	1,670	75	948
Printing	1,813	12,473	71	491	1,884	12,964	1,396	1,610	54	220
Railroad-shop construction and repairs	442	8,000	53	955	495	8,955	56	157	33	305
Stone, clay and their products	848	14,425	1,213	20,635	2,061	35,060	665	1,672	102	291
Textiles	1,074	4,711	301	1,783	1,375	6,494	825	758	270	347
Tobacco	111	593	89	473	200	1,066	165	174	2	24
Vehicles for land transportation	15,780	180,960	7,350	84,302	23,130	265,262	12,250	13,400	1,800	7,930
Miscellaneous	3,450	24,760	3,480	24,940	6,930	49,700	4,515	3,400	210	3,320
Totals for all manufacturing industries and mines in Michigan	52,964	614,954	25,990	385,264	78,954	1,000,218	34,665	46,469	4,926	28,461

Approximately half the electrical energy utilized in the Michigan industries is purchased from the public utilities. This represents 53.6 per cent of the entire amount, while that generated in private plants is 46.4 per cent, the totals being, purchased 798,159,000 kw.-hr., and privately generated, 690,992,000 kw.-hr.

Steam engines predominate among industrial drives, as indicated in Fig. 3. They constitute 69.5 per cent of the total driving power; steam turbines, 23.2 per cent; internal-combustion engines, 2.2 per cent; and waterwheels, 5.1 per cent. The average units for all industries are: Steam engines, 186 hp.; steam turbines, 821 hp.; internal-combustion engines, 51.5 hp.; waterwheels, 118 hp. In Fig. 3 is shown, graphically, the distribution of prime movers in each industrial group. Waterwheels are prominent in the paper and pulp as well as food and products groups; the iron and steel group also contains an appreciable percentage.

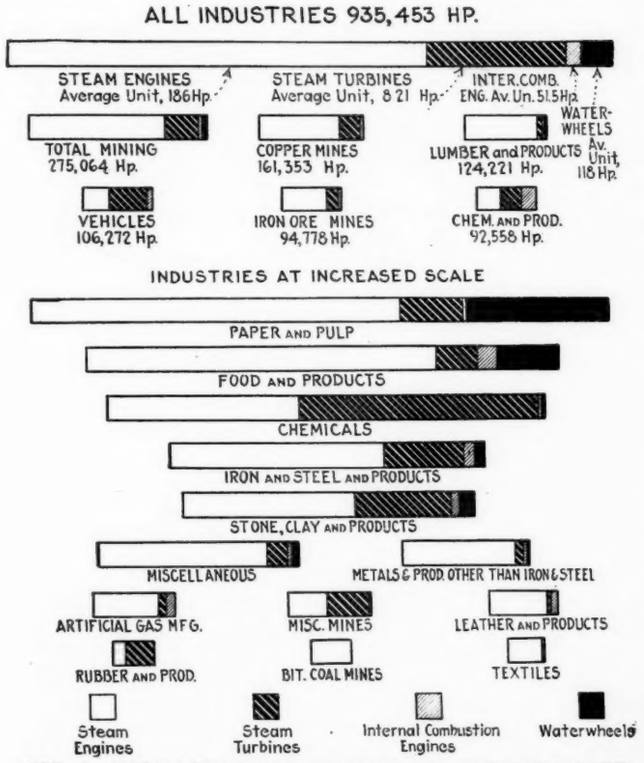


FIG. 3—STEAM TURBINES EXCEED ENGINES IN THREE INDUSTRIAL GROUPS

The rubber industry of Ohio, as shown in the 1920 Industrial Survey, contains an exceedingly large proportion of steam-turbine prime movers. In the case of Michigan this group is approximately 70 per cent steam-turbine driven. Chemicals and products utilize 55 per cent and vehicles 55 per cent of the steam turbines. Large units appear to have been used in the mining industries, where the average size is practically 2,000 hp. It is worthy of note that the total private steam-turbine horsepower for all industries is estimated at 217,390 hp.; the Ford Motor Co. has under construction six steam turbines which, when finished, will total approximately 250,000 hp.

Direct-current generation is usually characteristic of small isolated plants, as well as for mines and electrolytic processes. In the entire Michigan industries alternating-current generators predominate over those for direct current by a ratio of approximately 3 to 2. Direct-current generators represent greater capacity in the industrial groups of food and products; total mining, including each individual mining group; printing, textiles and miscellaneous. In the last-named group, especially, composed of small installations, direct-current generators have a 5 to 1 ratio to alternating-current. Alternating-current capacity is especially notable in the total chemical industries, where it is about five times that of direct-current, as well as in the paper and pulp group, with practically a 3 to 1 ratio. The average direct-current generator is 135 kw. and alternator, 354 kilowatts.

Motors using purchased energy total 614,954 hp., against a total of 935,453 hp. representing privately owned prime movers. In other words, the privately owned prime movers represent roughly 60 per cent of the driving capacity and the motors using purchased power 40 per cent, as shown in Fig 1. Mechanical drives are practically equal to, or slightly greater in capacity than electrical generators. Judging from the capacity of its prime movers, it is evident that if the power furnished is in this proportion, then the total privately generated power, including that furnished through mechanical drives, must exceed greatly the amount of electrical energy purchased by the Michigan industries.

Burning Oil in a Stoker Furnace

By A. A. Fette

The New Iberia, La., plant of the Chas. Boldt Paper Mills was designed to use coal for fuel. But during the erection of the plant fuel oil was offered at rates that were attractive and it was decided to provide facilities for handling either coal or oil. The arrangement of

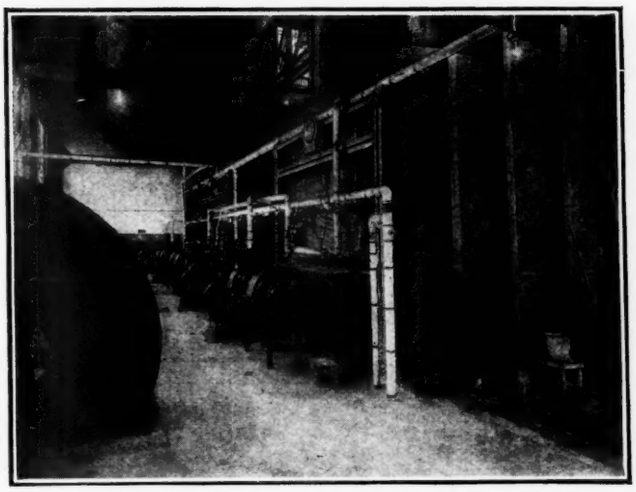


FIG. 1—BOILER FRONTS WITH OIL PIPING

stokers and piping for the oil burners is shown in Figs. 1 and 3, while Fig. 4 outlines the system of checkerwork.

In arranging to burn oil, the stokers were left in place and the brick checkerwork built over them as shown. Three I-beams were set into the bridge wall with the outer ends resting on firebricks placed on the top ends of the stoker bars. Two-inch pipes were cut to make a loose fit between the two side walls, and starting at the bottom with one pipe, a half-brick was placed on each I-beam. Then against this half-brick two more pipes were laid, followed by another half-brick, etc.

When all were in place, bricks were laid on these pipes as shown in Figs. 3 and 4 a little space being left around the walls which was filled with asbestos to allow for expansion.

The air ducts from the fan to the bottom of the stokers were never put in place, the openings being closed. Air is admitted through the ash tunnels, which

FIG. 2—DELIVERING OIL BY BARGE

are provided with slides that can be adjusted to alter the amount of air reaching the furnace.

Fifty-one 2x9-in. air spaces were left in the checkerwork. This allowed 0.2 sq.in. of air space per square foot of boiler-heating surface. During the erection of this plant the writer was quite busy and could not observe everything, and the laying of this checkerwork was not done properly. After about three months' operation, all the brick and pipe had to be torn out and relaid, for over half of the pipes had burned through and bricks were dropping out at a number of places.

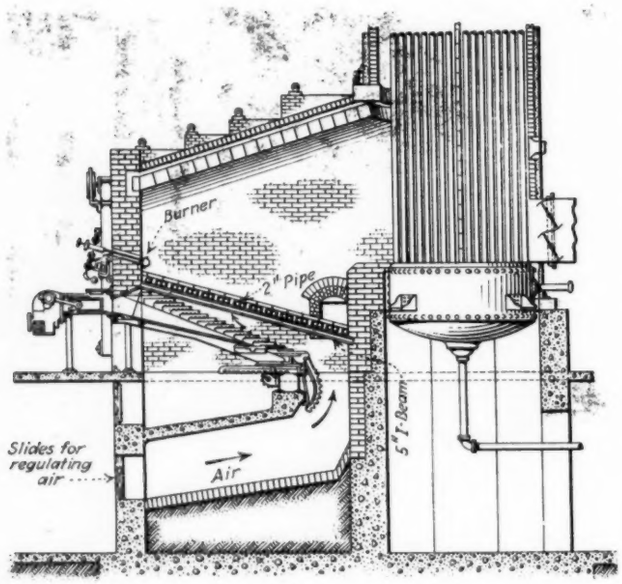


FIG. 3—CROSS-SECTION OF FURNACE

New pipes were cut to replace the burned ones, and the entire job was done under close scrutiny, special caution being taken that each joint came central over the two pipes. Asbestos was plastered into the corners of each air space to protect the pipe from excessive heat. The plant has been operating over a year since this was done, and the checkerwork is as good as new.

In case the oil is received by rail, a pump in the boiler-room basement pumps the fuel into the storage tank. When a barge delivers the fuel, as shown in Fig. 2, the oil is handled by the barge pump through a 6-in. line to the storage tank, the pump having a capacity of 1,230 bbl. an hour. This storage tank, which is 20 ft. 6 in. high by 32 ft. 9 in. diameter, has a capacity of 3,000 barrels.

The barges have a circular pipe coil around the suction pipe from the top to the bottom of the barge, for heating the oil to facilitate more rapid handling. Upon the boat's arrival the gager measures the oil in the tank while the crew makes connections. A metal tape line with a snap hook and a plump bob is let down in

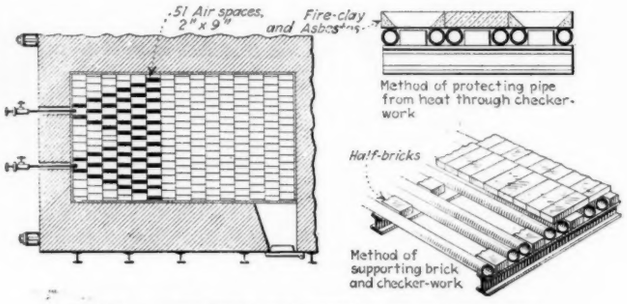

51 Air spaces, 2" x 9"
Fire-clay and Asbestos
Method of protecting pipe from heat through checker-work
Half-bricks
Method of supporting brick and checker-work

FIG. 4—SYSTEM OF CHECKERWORK USED

the oil until the tip of the bob touches bottom. Then it is drawn up and the height of oil jotted down. A thermometer is snapped into the hook and let down about halfway into the oil and held there a few minutes. The temperature recorded is jotted down, after which the pumping proceeds. When the tank is filled, the same process is again resumed, the height of oil and the temperature being entered on the delivery slip.

A table of the cubic contents of the storage tank furnished by the manufacturer states the gallons for every inch in height of the tank. By using this table and correcting for any variation of temperature from 60 deg., the net amount of oil received is ascertained.

The advantage of correcting for temperature is shown by the fact that the correction usually means a net saving of the price of over 51 lb. of oil. This is a point often neglected.

The oil from the supply tank is delivered to the burners by a duplex pumping set consisting of two 5½x3½x5-in. steam-driven pumps, which are provided with strainers, oil heaters, pressure regulation, etc.

Originally, the pipe lines from pumps to burners were arranged in a loop, as shown in Fig. 1. Since then a second heater and burner meters have been installed and the loop, although still there in case it is ever needed, is no longer used.

Each furnace receives its oil through its own meter. When these meters were installed, it was found that apparently one boiler was being forced twice as much as the others. It was a case of optical illusion, the foreman determining the amount of valve opening by the appearance of the flame. Since meters are in operation, the oil consumption in each furnace is almost equal. There is a bypass at each meter, and the bypass valves leading to the return line are kept open about a half turn to insure hot oil at all times.

When a burner is shut off, all oil is blown out of the strainer, pipe and burner tip to prevent carbonization. An extra burner is kept on hand to be inserted in case trouble is experienced with one in operation.

Cost of Oil-Engined Central Stations

The majority of small central stations, whether municipally or corporately owned, have turned to the oil engine as the most economical prime mover for this class of work.

In such plants where the load does not exceed 300 to 400 hp. even at the peak period and averages much under this amount, the semi-Diesel and solid-injection engines are generally conceded to possess a superiority over the more expensive although more economical Diesel. The latter machine under a high load factor will undoubtedly show a lower total cost per kilowatt-hour, but when the average load is small compared to the engine rating, the higher overhead charges often more that offset the lower fuel and lubricating consumptions.

The town of Plaquemine, La., when planning the purchase of a new light and water system was confronted with the problem that the lighting load would not exceed 300 hp. even at the peak period and during twenty hours of the day would not be over 115 hp. even when furnishing power to the water-works pumps. After due investigation the mechanical-injection engine was decided upon by the consulting engineers, bids being received from builders of both semi-Diesel and of solid-injection units.

To arrive at the proper engine to purchase, it was necessary to tabulate the consumption of fuel oil and of the lubricating as guaranteed by the bidders. In order to be conservative, an unusual maintenance charge of 2 per cent of the initial cost was used, while depreciation and insurance were set at 7 per cent, making the estimated life of the engine 20 years. Interest charges were not tabulated since the plant-operating costs were the deciding factors and the costs per kilowatt-hour, together with the estimated yearly output would enable the city authorities to determine how much revenue would be necessary to meet operating costs and provide for a bond sinking fund.

The material called for embraced briefly:

Item 1, One 150-hp. and two 300-hp. engines.

Item 2, One 100-kw. and two 200-kw. generators and exciters.

Item 3, One 5-panel switchboard.

Item 4, Necessary wiring and conduits in the plant.

TABLE I—SEMI-DIESEL ENGINE COSTS

Bidder	Engine	Type	Cycle	Brake Horsepower	Piston Speed, Ft. Per Min.	Cubic Yards in Foundations	Cost of Foundation	Total cost of 3 units Installed	No. of Cylinders	R.P.M.	Bore and Stroke, In.	Indicated M.E.P. Lb. per Sq.In.	Mech. Eff., Per Cent	Speed Regulation, Per Cent	Diam. of Shaft, In.	Size of Crank Bearing, In.	Size of Main Bearing, In.	Flywheel Dimensions, In.	Weight of Flywheel, Lb.	Weight of Engine, Lb.
A. Baldwin & Co.	Anderson	K	2	165	771	16.5	$239.25	$49,990	3	257	14 x18	36	86.4	2	7¼	7½x7½	7½x15	62x10	3,000	40,000
				325	771	28.5	413.25		6	257	14 x18	36	87.1	2	8	8½x6½	8 x12	62x10	3,000	50,000
A. M. Lockett & Co.	Worthington	Vertical	2	150	738	55.0	797.50	53,193	2	277	15½x16	53	70.0	4	8½	8½x8½	8½x13½	.....	4,760	39,900
				300	738	68.0	986.00		4	277	15¼x16	53	70.0	4	8¼	8¼x8½	8¼x13½	.....	4,760	64,500
Fairbanks-Morse & Co.	F. M. & Co.	Y	2	150	728	50.0	725.00	48,500	3	257	14 x17	35.5	85.5	3	7	7½x7½	7 x13¼	.....	3,500	38,000
				300	728	61.0	884.50		6	257	14 x17	35.5	85.5	3	7	7½x7½	7 x13¼	.....	3,500	60,000
Buckmaster-Lucke-Mall.	Standard	KV	2	150	642	23.0	333.50	51,220	3	257	10½x15	75.0	77.0	..	6½	6½x6½	6½x10½	78x8	4,500	37,000
				300	642	33.0	478.50		6	257	10½x15	75.0	77.0	..	6¼	6¼x6¼	6¼x10¼	78x8	4,500	55,000
De La Vergne Eng. Co.	De La Vergne	SI	4	185	771	55.0	797.50	54,000	3	257	14½x18	73.0	88.0	4	8	8 x8½	8 x12½	84x10	6,700	67,200
				300	771	70.0	1,015.00		5	257	14½x18	73.0	88.0	4	8	8 x8¼	8 x12½	84x10	6,700	115,420

Bidder	Fuel Consumption, lb. per b. hp. Load: Full	¾	½	Lub. Oil, Hp. Hrs. Per Gal.	Fuel Oil Consumption, Gal.: Small Unit ¼ Load 20 Hours	Large Unit ¾ Load 4 Hours	Lub. Oil Consumption, Gal.: Small Unit 20 Hrs.	Large Unit 4 Hrs.	Total 24 Hrs.	Cost of Lub. Oil Dollars: Per Gal.	24 Hrs.	Cost of Lub. and Fuel Oil: 24 Hrs.	365 Days	2 Per Cent per Annum Maintenance, Dollars	7 Per Cent Per Annum Depreciation & Ins., Dollars	Total Maintenances Depreciation and Ins., Dollars	Operating Cost for 365 Days, Dollars	Operating Cost Same Basis Per Kw.-Hr., Dollar,
A. Baldwin & Co.	.5	.54	.59	800	178.2	70.2	4.125	1.625	5.75	0.45	2.59	12.53	4,573.45	999.80	3,499.30	4,499.10	9,072.55	.01084
A. M. Lockett & Co.	.48	.51	.61	2,000	153.0	61.2	1.5	.60	2.1	.75	1.58	10.15	3,704.75	1,063.86	3,723.51	4,787.37	8,492.12	.01110
Fairbanks-Morse & Co.	.5	.52	.6	2,000	156.0	62.4	1.5	.60	2.1	.45	.95	9.69	3,536.85	970.00	3,395.00	4,365.00	7,901.85	.01042
Buckmaster-Lucke-Mall.	.48	.50	.55	2,000	150.0	60.0	1.5	.60	2.1	.75	1.58	9.98	3,642.70	1,024.40	3,585.40	4,609.80	8,252.50	.0108
De La Vergne Eng. Co.	.45	.45	.50	2,000	166.5	54.0	1.85	.60	2.45	.75	1.84	10.66	3,890.90	1,080.00	3,780.00	4,860.00	8,750.90	.0098

* Fuel oil at 4 cents per gal.

Item 5, Two motor-driven, 1,000 gal. per min. centrifugal fire pumps.

Item 6, Two motor-driven 300 gal. per min. centrifugal pumps.

Item 7, Two motor-driven 250 cu.ft. air compressors.

Item 8, Nine transformers.

TABLE II—BIDS ON PLANT EQUIPMENT

Bidder	Items: 1 (1-Small Unit)	1 (2-Large Units)	2	3	5	6	7	8	11
Hayden Construction Co.									
Chambers & Bowers									
Montgomery & Sledge									
McIntosh & Seymour									
Gray Artesian Well Co.									
General Electric Co.				$5,211				$1,885.00	
Dixie Mill Supply Co.									
A. Baldwin & Co.	$9,890	$33,750			$5,466	$1,905	$4,293		
Southern Jobbers Supply Co.					4,282	2,346		2,034.00	
De La Vergne Machine Co. Co.	12,000	40,000							
Carl S. Nadler									
Fulton Iron Works									
Fairbanks-Morse & Co.									$78,545.50
Buck., Lucke & Malochee						2,180	3,830		
Hadfield-Penfield Steel Co.	10,930	37,860							
A. M. Lockett & Co.	10,517	40,476			4,574	2,184	3,694		83,062.00
American Cast Iron P. Co.									
Baton Rouge E. & M. Wks.									
National Cast Iron Pipe Co.									
National Pump Co.									
Columbian Iron Works									
L. S. Vallely & Co.					5,910	1,930	3,940		
Chicago Pneu. Tool Co.							3,735		
Westinghouse El. Mfg. Co.			12,459	4,710				2,075.00	
Interstate Electric Co.				5,530				1,978.50	

Item 9, Hauling machinery, etc.

Item 10, Installing item 1 to 8.

Item 11, Items 1 to 10 combined bid.

The bids on the engines, together with the data as to part sizes, fuel consumption, estimated operating costs, etc., are shown in the Table I. These bids are for the

engines alone, while the contract as finally let to Fairbanks Morse & Co., covered all the items listed, at a total price of $78,545. The bids on the several items are shown in Table II. Deducting $10,452 as the price of the water-works material under items 4 to 8 gives a total of $68,093 for the generating equipment, this being equal to approximately $90 per horsepower of installed capacity, or $136 per kilowatt.

The Economical Use of Water in Hydro-Electric Plants

By Ralph Brown*

In those rather numerous plants where the capacity of the forebay is such that very little water can be stored or impounded during periods of low flow, the power-house draft should exactly correspond with the stream flow, the forebay elevation being maintained just at the point of spilling in order to obtain the highest kilowatt equivalent. There are, however, two exceptions to this statement, one being that on a Saturday or on any day preceding one during which the stream flow will be greater than that required for generation, the output should be sufficiently increased to lower the forebay elevation to permit of storing the water that would otherwise be wasted on the day of light load. Where advantage is taken of a holiday or Sunday to store water in this manner, the elevation of the forebay should not be lowered to such an extent that it cannot be restored to normal by the time, such as early Monday morning, that the total flow can be utilized, or should the forebay elevation be made so low that, owing to decreased head, little if any increase in output, as compared to that which could have been generated had the head remained constant, is obtained from the water discharged to make storage space available. The other exception is that when increased flow is predicted, the elevation of the forebay should be lowered, at the same time maintaining the highest average head possible in order to obtain the maximum amount of energy from the excess water discharged, to that point from which it can be restored without the power-house draft being reduced below the low-flow value and without a reduction in output due to decreased head.

Predicting Stream Flow

Besides the problem of utilizing a given quantity of water in the most economical manner and distributing the power generated at the highest efficiency, it is essential, if the best results from many developments are to be obtained, that sufficient study be devoted to conditions affecting stream flow to enable close predictions of this quantity to be made. Such an estimate should be made daily, to cover the 24-hour period beginning at midnight, and the kilowatt-hour output available for the same period depends upon the flow, generated kilowatt equivalent, and the amount of water impounded, or drawn from storage.

If stream-flow data are available over a period of years, close predictions of flow are possible, but lacking such data, an approximate estimate can be made by taking into consideration such factors as precipitation, temperatures, probable run-off, ice and snow conditions, weather reports, water stored or discharged at points upstream and the velocity of the stream.

Owing to the topography of watersheds tributary to most streams on which low-head stations are located, and because of the large quantity of water required, storage is generally impractical, and largely for this reason accurate predictions of stream flow are essential. It is usually feasible, however, to construct reservoirs for storing water for high-head plants, and where such reservoirs are employed estimates of stream flow are not so important, but careful study is generally required to determine, from records of precipitation and surveys of accumulated snow, the amount of water that will be available for storage and, especially during periods of drought, how water in storage may be most economically utilized.

Flashboards of various types are widely employed to increase the hydraulic head and the storage capacity of forebays and dams, and the profit accruing from their use can sometimes be materially increased by reducing leakage to the minimum and by the use of flashboards of the greatest possible height.

How To Prevent Leakage

An excellent method of preventing leakage is to nail strips of canvas to the bottom of the flashboards, placing cinders on the crest of the spillway, against the flashboards and canvas to insure a watertight joint. The leakage can be reduced to a negligible value by this method, even under a head of several feet, provided the cinders are kept in place against the bottom of the flashboards. Equipment, possibly so elaborate as to include floating derricks and launches, should be available for quickly and safely placing and removing flashboards. At small plants, where elaborate equipment is not needed, special hand tools can often be devised to greatly facilitate flashboard work.

The height and time of placing and removing flashboards should be based on accurate predictions of stream flow, and by careful planning it should be possible to remove the flashboards intact on the approach of flood conditions.

In low-head plants the possible loss of head due to obstructed trash racks is a greater percentage of the total head than in high-head plants, hence it is particularly important that trash racks or screens be kept clean where the head is low. The frequent removal of accumulated débris by raking will ordinarily not suffice for cleaning, for in most streams the trash racks will gradually become encrusted with a hard, dense substance that can be removed only by means of a wire brush, chipping or sandblasting. It is necessary, then, to have sufficient spare screens to permit of periodically withdrawing the ones in service, and after the removal of the encrustation thereon, it is advisable to apply, by means of an air brush, several coats of red lead and oil or some other preservative paint.

If an induction motor designed for 60 cycles is operated at rated voltage on 50 cycles, the results are: The field strength is increased, but the iron loss remains about constant. Magnetizing current is increased. The constant losses—core loss, windage and friction—remain approximately the same or, if anything, are slightly reduced, because, while the flux densities increase 20 per cent, resulting in a probable slight increase in core loss even on 50 cycles, the reduction in windage and friction at the lower speed is likely to more than offset any added core loss. The reactance on 50 cycles is lower than at 60 cycles, thus increasing the short-circuit current starting and pull-out torques.

*The Great Western Power Company.

EDITORIALS

F. R. LOW, EDITOR

Designing Power Plants by Impulse

ONE of the leading humorous periodicals has, for years, used the slogan, "Obey that impulse!" to get the prospective subscriber to sign on the dotted line. There seems to be no particular harm in this exploitation of impulse. But there are fields where impulse, uncontrolled by investigation and experienced judgment, is a dangerous thing.

Such a field is power-plant design. It may seem unnecessary to emphasize such an obvious truth, but the fact is that many a power-plant contains some features of design chosen much as one selects a tongue tickler from a box of assorted chocolates.

The hobby instinct, which is often harmless when applied in moderation to one's own personal affairs, may become a highly dangerous thing in the man who controls or influences the expenditure of thousands of dollars on engineering projects. Fortunately, our best designers, while not always above criticism in this respect, have largely schooled themselves, through years of rigid analysis of all proposals, to overrule their whims and impulses and get what pleasure they can from the consciousness of having solved their problems in the best manner possible within the limitations of their ability and the state of the art. But, unfortunately, the hands of the designer are not always free. The owner, contractor, or perhaps some officer of a bank that has loaned money for the project, mistakes authority for ability and insists on changes here and there to suit his particular hobby. Where the man is emboldened by a smattering of engineering knowledge, this interference is likely to reach serious proportions.

Designers and consulting engineers are still looking forward to that Utopian era when the promoter of a project will come to them and say: "Here is my problem. Solve it in such a way as to give me the greatest return on my investment. Give due consideration to my suggestions, but make your own engineering decisions and be prepared to accept full responsibility for the results."

Who Should Have Instruction Books?

THAT we should take a pride in personal accomplishment is conceded without argument. Unfortunately, this matter of self-appreciation often becomes of such volume that after performing a valuable piece of work, the originator, author or worker thinks too highly of his product to put it to use or even submit it to the light of day.

On no other grounds can one explain why a manufacturer, after spending much time and money in preparing an instruction book on his machine, should refuse to give the set of instructions the widest publicity. Evidently he thinks too highly of it to allow it to fall into profane hands.

Recently *Power* received a letter from an engineer who has charge of a Diesel engine in an obscure part of the world. The engine builder had furnished the plant owner with a very complete instruction book. This has disappeared, and since two or more of the officials have left, it was no doubt mislaid by one of them. This operating engineer is interested in the machine in his care, so much so that he has written several times to the engine builder for another instruction book. Up to date this has been refused him on the grounds that it is the firm's rule to give only one per customer.

The engine builder may believe that the set of instructions contains information valuable to, and at present unknown to, his competitor. If so, he is laboring under an error, for the book has been photostated at different times and at others certain portions copied. All that has been accomplished is the withholding of information from the very man who should be given every incentive to learn the peculiarities of the engine he is operating.

If one were to outline a plan of campaign to bring the oil engine into disrepute among engineers, undoubtedly one of the plans of attack would include the withholding of all information and the enveloping of the subject in a mantle of mystery.

Importance of Inspection and Maintenance

REGULAR periodic inspection and testing of equipment is a practice in power-plant operation and maintenance that is now recognized as being economically sound. The most expensive repairs are generally those that have to be made after a breakdown has occurred. If the defect is discovered before failure occurs, repairs can be made at a minimum of expense and at a time that will cause the least inconvenience in operation of the station. The unexpected failure of a part in a machine may not only cause a shutdown at an inopportune time, but getting the machine back into service may be seriously delayed on account of the time required to obtain the material for making the repairs.

In making repairs there are two costs to be considered, the actual expense in labor and material to put the machine into operating condition and the loss of revenue due to the machine being out of service or the increased cost of operation on account of having to operate less efficient machines to help carry the load in the emergency. In the case of a water-power plant operating during a high-water period under conditions where there is sufficient load to keep all machines loaded twenty-four hours a day, where power is sold at only one-half cent per kilowatt-hour, the failure of a ten-thousand kilowatt machine represents a loss of twelve hundred dollars for each day the machine is out of service, in addition to the cost of making the repairs. This example emphasizes the importance of careful inspection, testing and maintenance of equipment in river-flow hydro-electric plants. During periods of low water, when only part of the machines can be operated, every

effort should be made to put the equipment in a condition that will insure reliable operation during high-water seasons, when all the generating units will be needed on the system.

On the other end of the scale is the plant that has sufficient capacity so that one machine can be taken out of service at any time for repairs without inconvenience to the system load. Even under this condition lax methods in inspecting and maintaining equipment cannot be justified. In the first place, if a defect is allowed to develop into a failure the cost of the damage done may be increased many times. There are numerous cases on record where a complete wreck of the machine has occurred due to some defect that could have been easily detected and repaired at small cost if proper precautions had been observed when inspecting the equipment.

In the steam-electric station it is necessary to keep the most efficient machines in service to obtain the highest economy. This also applies to hydro-electric stations where machines of different capacities are installed and a limited amount of water is available; the most efficient machines should be operated so as to obtain the greatest number of kilowatt-hours from the water available. Maximum service from the most efficient equipment can be obtained only by careful inspection and maintenance.

When old, inefficient equipment is operated in case of failure of more efficient machinery, the difference in economy may easily be as high as fifty per cent in steam stations, and the difference in cost of operation is chargeable to the expense of making repairs and having the better equipment out of service. In figuring the cost of repairing a failure in a piece of equipment, not only the cost of the actual repair but also the loss of revenue and increased operating expenses due to the machine being out of service must be included. When this is done, the importance of proper inspection and maintenance takes on a double significance.

Deriving Theory from Practice

"IT MAY be all right theoretically but practically it's a nuisance." Those connected with practical power engineering, operating, erecting and correcting troubles, have probably heard such a sentiment expressed, and more often thought or forcibly given voice to it themselves. Machinery in general, as calculated and designed, requires a testing and improving period before it is thoroughly suitable for commercial operation.

"Theory" ordinarily receives rough treatment at the hands of the practically experienced man. His suspicions are naturally and properly on the alert when radical departures are introduced. The man at the drawing board must not only foresee future conditions, but develop suitable designs, limited by commercial costs. The advantage, if any, must lie with the one who has the machine itself to deal with, and definite known trouble to be corrected. His solution may consist of several expedients, to be tried and compared, whereas the designer is expected to hit the target in the beginning.

Theory, however, as represented by experiments and conclusions, has undoubtedly scored heavily against practice in some instances. The application of self-aligning pads for bearings, particularly thrust bearings of the Michell and Kingsbury types, is essentially related to the Reynolds lubrication theory. Research and its application have here produced bearings for heavy pressures far superior to others in commercial use.

Characteristics of electrical phenomena are usually too much involved for accurate human judgment. Theory and its application have become so refined in many directions that results may be produced as desired, with an accuracy beyond reasonable criticism.

Conditions in a transmission line may be such that a short-circuit at some point will not prove injurious or even unsafe. Practical experience under like conditions may predict such results and be just as reliable a guide. Theoretical calculations, however, may express the effects for a variety of factors and define the safe limit in a comprehensive manner beyond that possible by human judgment alone. Not only this, but the results of a short-circuit occurring in totally different conditions, possibly never before observed, may in many instances be figured to a high degree of accuracy, sufficiently close, at least, to serve as the basis of choice or rejection.

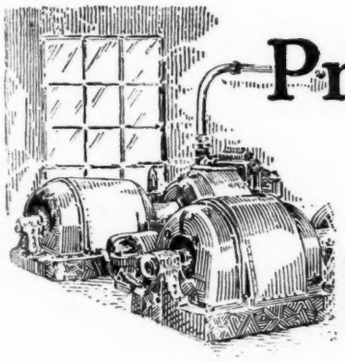
Not long ago college textbooks contained practically nothing about the growth of valves and fittings due to the effects of steam. Engineering graduates may have discounted the stories of engineers relative to cast iron "growing" in service and the necessity of protecting the valve seats from the direct impact of steam, even at moderate temperatures. Recent steam conditions have accentuated these difficulties; theory and research now testify to the existence of former troubles of the practical man as an authenticated phenomenon.

Theoretical investigations sometimes reveal unexpectedly what is already quite familiar to unscientific experience. In recent investigations of the fatigue of metals it was revealed that fatigue conditions tended to increase the modulus of elasticity of steel. Practice has shown that springs used for governing devices, where elasticity is an important factor, tend to become stiffer with age, which is merely another way of expressing the same result.

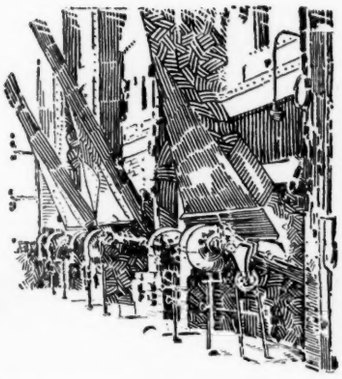
Recent developments in the investigation of lubricating phenomena in England indicate that viscosity and friction are not related in the way that the Reynolds theory indicates. This holds that friction depends on the viscosity and the mechanical condition of the film, rather than the nature of the lubricant. Tests, however, show that a wide difference of friction may be produced with a small variation of viscosity, practically negligible. Engineers have long known that for some applications, vegetable oils give appreciably less friction than mineral oils of equal viscosity. An investigation has pointed to an answer along equally well known lines. Glass will be wet by water but not, practically speaking, by mercury. The ability of the lubricant to wet the separated surfaces, or to "adsorb" in scientific language, is held as an explanation. Vegetable oils are known to have this adsorbing power in some instances to a greater extent than mineral.

There are perhaps many phenomena familiar to practical experience in manufacturing or other lines which will eventually be developed from an analytical point of view. It would seem to be advantageous for the scientific investigator to look up the results of practice that may have a bearing on any subject under analytical examination.

Power-plant engineering is no field for the fellow that wants to "learn the job" and then settle back, fixed for life. With new developments continually coming to light, the man who stops studying even for a few months begins to slip behind the procession.



Practical Ideas *from* Practical Men



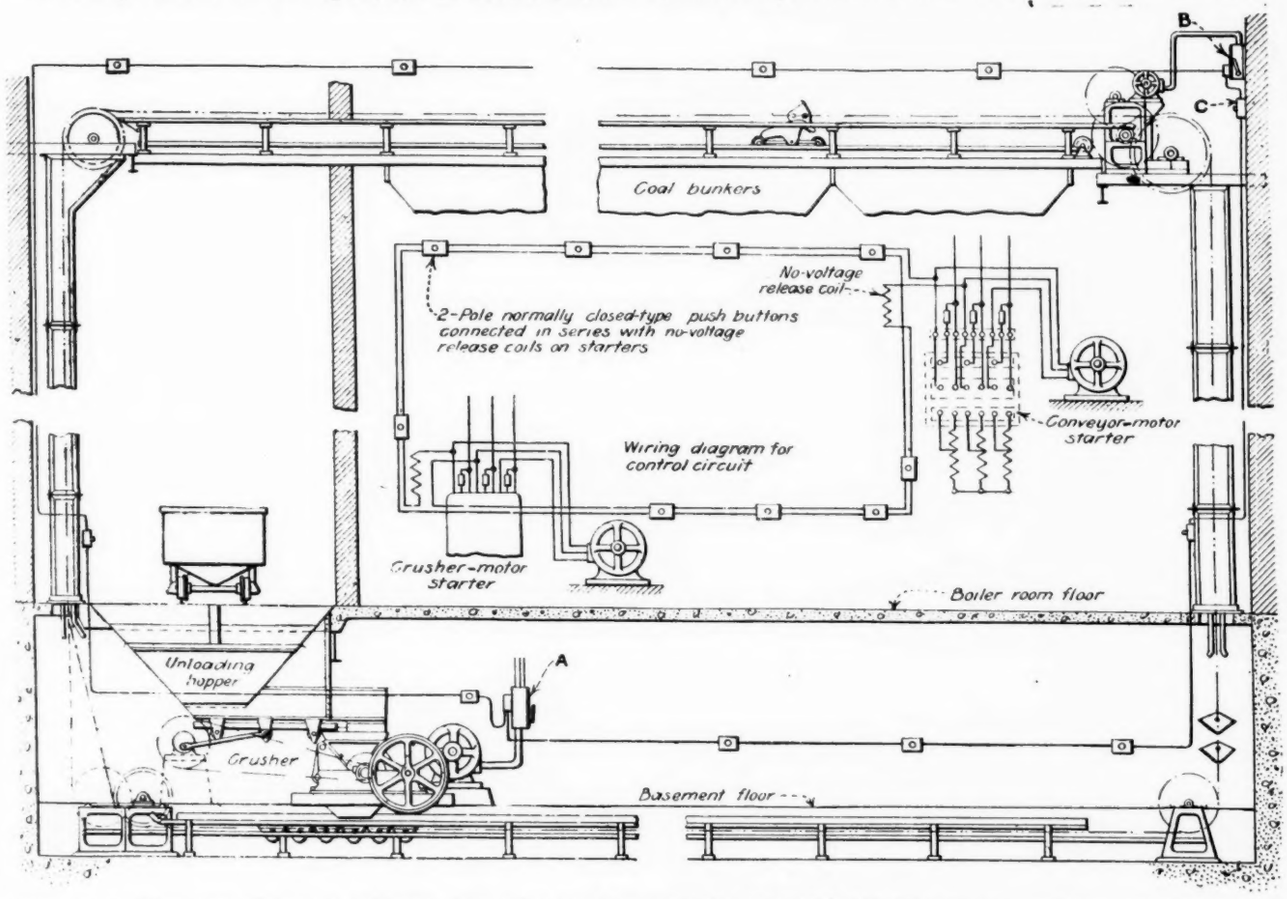
Control Circuit for Coal Conveyor and Crusher

The illustration herewith shows the coal crusher and conveyor equipment as installed at our plant and is, I think, a typical installation for this kind of equipment.

As our daily coal consumption is not very large, one man usually looks after the operation of both the conveyor and the crusher, and this formerly entailed climbing up and down from the boiler-room basement to the walkway about the coal bunker, to start or stop the machines as the case might be. Also, in the event of any trouble on the conveyor when the operator happened to be in the basement, considerable time elapsed before he could reach the starter and shut the conveyor down.

After considerable trouble had been experienced with the conveyor and a few breakages had occurred through not being able to stop it readily, it was decided to install a control circuit whereby the conveyor and also the crusher could be stopped from any point along the route of the conveyor.

As the starters were already equipped with no-voltage release coils, the connection on one side of the coil on each starter was opened and a number of two-pole normally closed-type push buttons were connected in series with them and arranged on two independent circuits as shown in the wiring diagram. The control circuits followed closely the route of the conveyor as shown, and the push buttons were placed in accessible positions about 20 ft. apart. No. 12 double-braided rubber-covered wire was used for connecting up the push buttons.



PUSH BUTTONS CONNECTED IN SERIES WITH NO-VOLTAGE RELEASE COILS ON STARTERS PERMIT STOPPING THE MACHINES FROM ANY POINT ALONG THE ROUTE OF THE CONVEYOR.

and both circuits were pulled in ½-in. conduit. The no-voltage release-coil connections are usually made inside the starter, but for the sake of clearness are here shown made outside the starter.

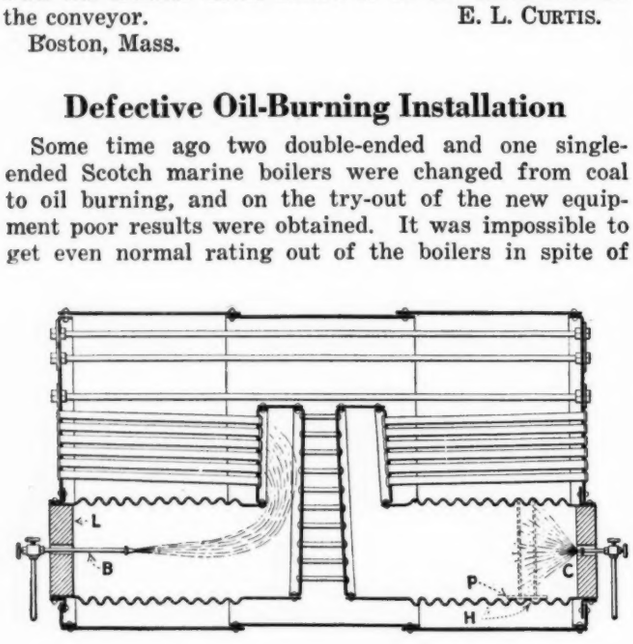
It is now possible to shut down the conveyor and crusher from any point without delay, and this has lessened materially the work of the conveyor operator. It is also possible to shut the crusher down from push button *C* and still keep the conveyor running by simply holding the starter *B* in the running position when the push button is opened.

It is obvious that independent single-pole push buttons could be used on each circuit, but there would be little to be gained by doing this, as it is necessary to shut the crusher down before or at the same time as the conveyor. E. L. CURTIS.

Boston, Mass.

Defective Oil-Burning Installation

Some time ago two double-ended and one single-ended Scotch marine boilers were changed from coal to oil burning, and on the try-out of the new equipment poor results were obtained. It was impossible to get even normal rating out of the boilers in spite of



SHOWS CHANGE MADE IN BURNER INSTALLATION

any adjustment we could make to the burners or drafts. At last it was put up to the chief engineer to get results or throw out the burners and use coal again.

The chief made a careful study of the action of the oil fire and concluded that the gases were carried through the tubes to the stack before combustion was complete. The burners extended through the front lining a considerable distance, as at *B*, and sprayed the oil almost to the back of the firebox before ignition really took place. These burners were constructed with one tube inside of the other, and the atomization took place in such a manner as to produce a long flame. It was apparent that the flame should be brought back nearer the front of the firebox; accordingly, one burner was removed and cut off as shown at *C*, which allowed the oil to spray out close to the burner. This burner did not quite pass the inside edge of the front furnace lining, and the oil sprayed over the entire firebox and more perfect combustion resulted. This proved to be so much better that the burners were all cut off and the installation then gave satisfactory service.

Some time later a hole appeared in the flue sheet at *H*, and the water sprayed up into the oil flame and made the firebox practically useless. As the boiler could not be spared at that time, it was decided to cover the hole with a piece of ⅜-in. plate held in place by two pieces of pipe as shown until the boiler could be shut down. This prevented the water from spraying directly into the flame, and the furnace was used for two days before it was shut down for repairs. R. A. CULTRA.

Cambridge, Mass.

The Engineer Who Spoils Jobs

A few days ago, on visiting a plant in which some years back I had control of the engineering side, I was somewhat surprised to find the present chief arrayed in a boiler suit so dirty from long wear that it would have been a disgrace to a self-respecting workman. Before and during my time the position was considered a "collar and cuff" one, and the boiler suit appeared only occasionally for inspections that every chief must personally attend to if he intends having things right and taking no risks. But in this case I found, after inquiries from old workmen, that my successor was continually in uniform, that the plant draftsman had the only "collar and cuff" job going and was fast qualifying for the chief's position, and in my opinion the sooner he gets it the better for our profession.

Many engineers, I fear, are in a similar state as this one, not for lack of skill but from lack of respect for themselves and their profession, due to many causes, the most prominent being want of self-confidence, which is the first necessity if we are to lead and direct any organization or hold a position worth while. This state of affairs contributes more than anything else to the small salaries so often complained about by engineers, the majority of whom, I fear, are suffering from lack of confidence, and the best advice I can offer is to set about acquiring it by every means possible.

Personally, although I have no college training myself, I think the graduate gets more in the direction of self-confidence than anything else, hence his success in many instances over the practical man, but this is no reason why the latter should get into a rut and spoil a good position. Educational facilities compared with forty years ago are very much improved, and no one is too old to learn. Reading is helpful, but many, I fear, grudge the few cents necessary for a journal of this kind, overlooking the fact that it is not an expense but an investment and salary raiser of the first class, as I have proved. A copy lying on the desk or produced when occasion arises, creates an impression with the powers that be, especially when new plant is required and you can reel off the advertisements like a book. Writing will also help considerably, and why more of it is not done I cannot understand, as every engineer worth while has some story to tell, and if the practical man who today is spoiling a good job will take the hint, the time is not far distant when he can go on to the job in "collars and cuffs." F. P. TERRY.

Belfast, Ireland.

For the jackets of a compound air compressor the total water required for the two cylinders need not usually exceed 1 to 1½ gal. per 100 cu.ft. of free air. Thus, with reasonably cold water (60 to 70 deg. F.) a 2,800-cu.ft. compound compressor could get along on 35 gal. per min. for the two cylinder jackets alone. For the intercooler of a high-grade compound 100-lb. unit, it is usually safe to figure on from 2½ to 3 gal. per 100 cu.ft. of free air. On this basis the intercooler of the 2,800-ft. unit would require from 70 to 85 gal. per min., if the intercooler was of efficient design.

Comments from Readers

How To Test a Boiler

In the Aug. 14 issue I read an article on "How To Test a Boiler." The method outlined I believe is very good in case the performance is good, but will not point out the defective part of the apparatus if the performance is disappointing. I believe there is not sufficient attention paid to separating the boiler efficiency from the furnace efficiency.

The usual procedure is to take CO_2 and CO readings from the last pass of the boiler. This does not prove any furnace performance, as I have observed at many tests in taking simultaneous gas samples from the last pass and from the first pass, the CO_2 would increase 2 or 3 per cent between the first and the last even though there was practically no CO shown in the first pass. This, it seems to me, indicates that hydro-carbons were burning slowly and adding CO_2, the unburned hydro-carbon gases in the first pass not showing in the ordinary gas analysis.

It is obviously unfair to expect a boiler to absorb heat if that heat is being generated in among the boiler tubes, and I have noticed that this condition will in some cases raise the exit-gas temperature 100 or 200 deg. above what it should be, indicating an efficiency loss of from 4 to 8 per cent. This loss is due not to any defective boiler operation, but to poor stoker operation in not burning the fuel completely in the furnace.

Philadelphia, Pa. J. H. ROHRER.

Water Injection in Semi-Diesel Engines

In *Power*, Sept. 11, page 428, there is a reference to the introduction of water into a semi-Diesel engine cylinder and it is stated that the water serves to lower the temperature of the piston head and cylinder walls and that a greater weight of air trapped enables the engine to burn more fuel and develop more power. My observation is that the use of water is discredited by all who pretend to build a modern semi-Diesel, and for one good reason; that is, the chemical action due to water containing sulphur and other impurities is a disadvantage.

The writer, in discussing engine design in the *Automobile Engineer*, May, 1923, stated that "An auxiliary air port is also arranged on the exhaust side of the cylinder, the main reason for which is to reduce the temperature of the piston at its hottest side. This air is delivered at atmospheric pressure at the extreme end of the pumping stroke, but it is preferable to use an independent blower or air pump. This air volume should be sufficiently large to fill the crankcase volume plus about 10 per cent. The surplus air is used for scavenging and is a means of obtaining the largest possible volume of air at the time of fuel injection."

The writer believes that heat otherwise lost can to some extent be regenerated by absorbing excess piston heat. It is also a logical conclusion that the larger the air volume transferred in the usual semi-Diesel, the earlier is the ignition pressure obtained. In other words, if an incomplete volume is present at the beginning of the compression stroke, the volume at the point of ignition or injection must be reduced and the fuel it can use must be less, reducing the power for a given bore and stroke using the same compression pressure.

If the piston temperature can be reduced by the total air being delivered past and in contact with the inner end of the piston, the compression can be increased owing to the fact that the combustion time period is increased. As a result the hot bulb or firing pin is the only influence that will cause ignition, as against the result due to firing a charge at both ends, by means of a hot piston head and a device designed to operate and fire a charge.

To attain maximum air pressure and volume in a semi-Diesel using crankcase compression there is an important factor that appears to be sadly overlooked; that is, there seems to be no attempt to reduce the crankcase volume to a minimum. At best it is a poor excuse for a pump, due to excessive volume. Perhaps the only reason that it is not designed with a minimum volume, is that a limited air charge can be compressed to any desired pressure, while the bore and stroke is made to suit the power output with a limited air supply and fuel to suit.

The location of the transfer and exhaust ports with relation to the connecting-rod side thrust acting on the piston for a given direction of rotation of the crank, seems to be in every case just the opposite to what it should be.

I refer to the piston thrust (on the power stroke) being delivered on the transfer port side where the bore is weakest. In addition, any surplus lubricating oil in the crankcase is thrown into the transfer port and, passing upward into the combustion space, may and will cause the engine to show a higher fuel-oil efficiency. Why not deliver the piston side thrust on the exhaust-port side and reduce the lubricating-oil bill?

Cleveland Heights, Ohio. JAMES MCINTOSH.

Some Causes of Fire in Stored Coal

Referring to the inquiry of J. J. I. in the Sept. 4 issue as to the cause of fire in a coal pile, it is possible that the measures he has taken to ventilate the pile are one cause of his trouble. In general, coal piles seem to fail to heat owing to an insufficiency of air to generate the necessary heat rather than because the amount of air circulated carries off and dissipates the heat generated. This is shown by the greater frequency of fires in the autumn, when, with warm days and cool nights, the column of warmer air in the pile acts as a chimney and greatly increases the circulation at night. Recent opinion among power-plant operators who store large quantities of coal, seems to be along this line, and efforts are now being made, when piling coal, to eliminate the usual layer of lumps at the bottom of a pile resulting from the lumps rolling down when the coal is dumped from an overhead distributor. In some

cases tractors are used to roll down or pack the coal when being stored, to reduce the porosity of the piles and with it the air circulation to such an extent that there shall be no chance of heating.

J. J. I. does not say in what part of the bin the heating takes place, but with wet coal piled against a wooden fence or the presence of wood in a pile, heating is likely to occur. I have seen a good grade of semi-bituminous coal that was piled against a wooden fence take fire opposite the foot of each post after about six months, although it was winter weather.

External heat is also a cause of serious trouble, as the danger point of coal piled to any depth to give cover enough to prevent radiation, say 8 or 10 ft., is about 140 deg. F. It is seldom that coal that has heated to this temperature will cool of itself unless the pile is opened up so that it may cool rapidly. In one case a serious fire was started by a drain line that ran down the side of a coal pocket being heated by steam coming from a leaky valve. This line was rather deeply buried, and the fire spread some distance before reaching a trestle support, where the gases rose to the surface and gave warning of the fire.

A good check can be kept on coal-pile conditions by taking a 20-ft. length of ¾-in. round iron and pushing it down to the bottom of the pile and after leaving it about five minutes to come to the temperature of the pile, pull it out. If the rod is covered with wet coal dust and feels only comfortably warm there is no trouble, but if it comes out dry and too warm to hold onto for a few seconds, trouble can be looked for at that point in the pile, the position of the hot spot on the rod locating the depth. This is particularly true if a little gaseous odor can be smelt at the mouth of the hole left by the rod. If the heating has gone very far, a crust can be felt just before reaching the hot zone. The presence of this crust is one reason why water has little effect on a coal-pile.

It is my opinion that if J. J. I. will go over his bin carefully to see that it is not heated externally and will remove the boards from in front of the stone wall, also, when filling this bin level it up frequently so as to get the coal more uniformly distributed in horizontal rather than in conical layers, as occurs when dumped from above, he will have much less trouble with heating.

New Haven, Conn. H. D. FISHER.

Steam Should Not Be De-superheated

In an article in the Sept. 14 issue (page 366) A. G. Christie describes a method of de-superheating steam that is to be used in evaporators or closed heaters. He speaks of the "reduction of capacity of closed heaters due to the low rate of heat transfer with superheated steam." The idea that lower rates of heat transfer are to be expected when superheated steam is used in evaporators and heaters is erroneous. This has been prevalent among those concerned with this equipment and is advanced in one of the most modern treatises on steam turbines as an argument against using bleeder heaters on the higher pressure stages of turbines, where extracted steam is superheated.

This idea, it is supposed, originated from the experience of these men with superheated steam in other types of equipment. Some have, no doubt, supposed that lower rates of heat transfer in heaters were to be expected from superheated steam because of its tendency to reduce the amount of steam transferred from the unexpanded to the expanded steam in a reciprocating engine cylinder. This effect, as has been explained many times, is due to the smaller amount of initial condensation on the cylinder walls with the resulting increase in the mean cylinder temperature and not to any reduced rate of heat transfer with superheated steam. Others familiar with the fact that even with high steam velocities the transfer of heat from a superheater tube to the steam is very low, have not considered that the conditions in superheaters are much different from those in a feed-water heater.

Superheated steam should be preferred for feed-water heaters. In cases where low rates of heat transfer between superheated steam and metal surfaces are experienced, it will be found that the temperature of the film on the surface of the metal is above the temperature corresponding to the pressure of the steam. When this is the case, each particle of steam coming into the surface film can give up or take on only a part of the sensible heat of superheat, whereas when the temperature of the film is slightly cooler than the saturation temperature, the entering particles of steam give up the latent heat of evaporation in addition to the superheat.

Where superheated steam moving at low velocities is in contact with a surface that is warmer than the saturation temperature, the transfer of particles into and out of the surface film is accomplished mostly by the slow process of diffusion.

The heat transfer, however, is much greater when the temperature of the tube surface is slightly below the temperature corresponding to the pressure of the steam. The particles of steam coming into the surface film then not only give up several times more heat, but are condensed into water, thus scarcely interfering with the movement of other particles of steam to the heat transfer surface.

With the rapid diffusion resulting from the high steam velocities, the temperature of the tubes being higher than the saturation temperature of the steam, the rate of heat transfer in a superheater tube is low as compared to that obtained when stagnant superheated or saturated steam is being condensed in a heater or evaporator, where tube temperature is below that of saturation.

Where the other side of the heating surface is cooled by water, as in evaporators and heaters, the conductivity of the film between the water and the tube will be such that the tube temperature will remain below the temperature corresponding to the steam pressure even when highly superheated steam is used. In such cases the rate of heat transfer with superheated steam will be as high as that with saturated steam at the same pressure. This is shown by tests in the table.

RESULTS OF TESTS MADE TO DETERMINE THE EFFECT OF SUPERHEATED STEAM UPON THE HEAT TRANSFER IN EVAPORATORS

Steam pressure in coils, lb. sq.in. abs.	54.3	54.2
Temperature of steam entering evaporator, deg. F.	599.3	286.2
Superheat of entering steam, deg. F.	313.0	0
Temperature of vapor leaving evaporator	201.9	197.5
Temperature head in evaporators	84.4	88.7
Water evaporated, lb. per hr.	17,800	16,700
Lb. of water evaporated per deg. temp. head	211.0	183.5

The tests were both made on the same evaporator with all conditions maintained as nearly as possible the same. The temperature head was obtained by taking the temperature corresponding to the steam pressure rather than the actual steam temperature. These tests, as well as others that were made, indicated that super-

heated steam gave a higher heat transfer than saturated steam.

Where superheated steam is available, such as that extracted from the high-pressure stages of turbines or exhausted from small auxiliary turbines, it is therefore evident that more water may be evaporated by using superheated steam direct than by de-superheating the steam and using saturated. Approximately 6.5 per cent more evaporation is obtained in the test by using superheated steam direct.

These results are particularly interesting at the present time, since the tendency is to bleed steam from the higher pressure stages in turbines where the steam is superheated. The problem of using this superheated steam in heaters is simplified by not having to provide means for de-superheating the steam.

Springdale, Pa. B. C. SPRAGUE.

Reminiscences of a Veteran Mechanical Engineer

In his interesting article, "Reminiscences of a Veteran Mechanical Engineer" in the Sept. 18 issue, J. B. Stanwood refers to the low duty of the Hope Station pumping engine as built by Mr. Corliss for the City of Providence, R. I. He also refers to the matter of cylinder condensation.

May I say in the first place, that Mr. Corliss did not build the Hope Station engine with the expectation of high duty. He built it for a special service, as outlined in the July 10 issue. A little later he built a high-duty pumping engine for the City of Boston, which was as great a success for the service for which it was designed as the Hope Station engine was for the service for which Mr. Corliss designed it. This high-duty engine was designed to pump the sewage of Boston and force it far out to sea.

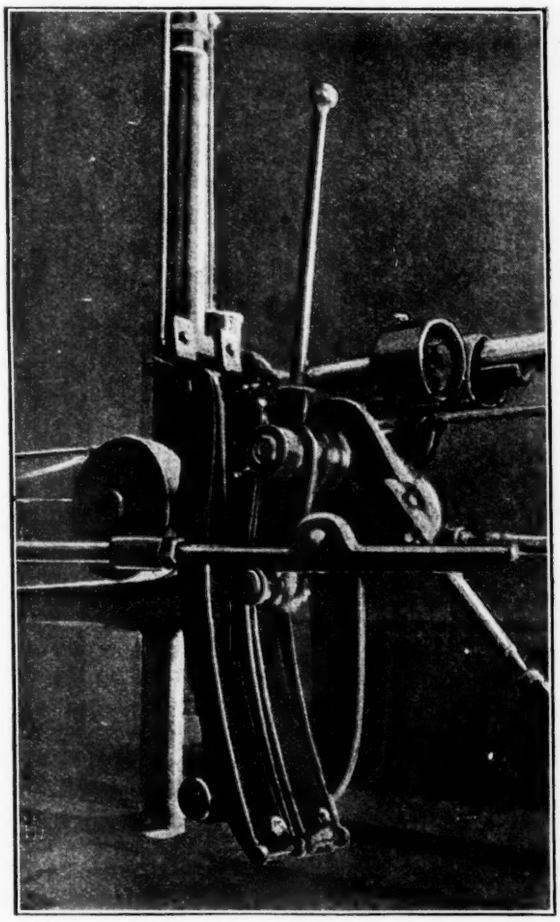
This sewage-disposal engine was set up out at the Corliss Works and was so well balanced that when in motion doing service, a lead pencil could be placed on end on the steam chest and would not fall. I cannot remember what the duty was, but I do remember it was highly gratifying to Mr. Corliss, and when he told me of the duty, he hit me a punch in the ribs and remarked, "I told you I could build a high-duty pumping engine." And he did.

I might also add that at the time of which Mr. Stanwood writes, very little was known about cylinder condensation. My first experience with this factor of economy was during the early seventies, when I was called on to make a duty test of the "Wells Balanced Engine." This engine used two pistons in one cylinder and ran at very high speed for those days. The duty was much higher than was to be expected from a plain slide-valve engine of that type, and I well remember the sleepless night I passed in trying to account for this higher duty, and finally settled the problem by reporting it was due to "reduced cylinder condensation," and then went around for several days with my heart in my mouth for fear someone would call on me to explain "why cylinder condensation." It was a shot in the dark, but no one seemed to know any more about it than I did, and subsequent events proved it had hit the mark. Are there any other veterans who can give us another "reminiscence" as interesting as Mr. Stanwood's has proved to be? W. H. ODELL.

Brooklyn, N. Y.

An Early Corliss Engine

The series of reminiscences by W. H. Odell which appeared recently in *Power* have been productive of much interesting discussion, especially with regard to the early Corliss engines. One reader calls attention to an old installation at the plant of J. B. Williams, Glastonbury, Conn. Upon inquiring, we find that this engine, which had been in service continuously since 1863 or '64, was scrapped about five years ago. However, through the courtesy of *The Locomotive* we are able to reproduce the photograph of the valve gear of the engine from a description that appeared in that paper in July, 1916.



VALVE GEAR OF EARLY CORLISS THAT OPERATED FOR MORE THAN FIFTY YEARS

The dimensions of the old engine were, stroke 42 in., cylinder diameter 16 in., and speed 66 r.p.m., the steam pressure being 100 lb. and the developed horsepower about 106. This engine differs from the type that we are accustomed to regard as the early Corliss engine in that the valve was pulled open by the eccentric against the restraint of a leaf spring; this spring is the means by which the valve was closed at cutoff instead of by the dashpots. Although dashpots were fitted, they opposed the closing of the valves and served only to cushion the seating of the valves under the stiff pull of the spring. Corliss built a few engines of the spring-lever type, but later adopted the wristplate design as used in the Harris-Corliss engines. The illustration of the valve gear shows the eccentric rod unhooked.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Correction of Too Early Admission

What would be the remedy for too early admission of steam in a plain slide-valve engine? C. E. P.

The time of the valve events of admission, cutoff, release and closure of the exhaust, with respect to the position of the piston, depends on the angular position of the eccentric with respect to the crank. By setting the eccentric backward, all valve events will be made to occur later in the stroke; that is to say, there will be later admission, longer cutoff, later release after cutoff has occurred, and later closure of the exhaust, with less compression.

Negative Slip of Boiler-Feed Pump

May not a feed pump deliver more water to a boiler than would be represented by the piston or plunger displacement of the pump? M. L. D.

Negative slip, or discharge of a pump in excess of the piston displacement, is not likely to occur unless there is a long suction pipe and long stroke of the pump, with discharge taking place against comparatively low pressure to resist the ram-like action of the suction water when the pump piston comes to a pause in its stroke. Hence conditions favorable to negative slip are rarely if ever present in the operation of ordinary boiler-feed pumps.

Effect of Rocker Out of Plumb

If the rocker of a Corliss engine oscillates one inch more to one side than the other of a plumb position. how will it affect operation of the valves? S. W. T.

If the rocker is to one side of a vertical position when the wristplate is in central position, there will be less movement of the wristplate on the same side and consequently slower movement of the valves, when operated from the wristplate while on the same side of its central position, than if the rocker were brought to a plumb position when the wristplate is at the central position. The reverse will be true of valve movements by the wristplate when on the other side of its central position. But for Corliss engines of ordinary sizes and usual proportions, a rocker only one inch out of plumb for central position of the wristplate would not perceptibly affect operation of the valves.

Wetting Down Coal

Is there any advantage or disadvantage in wetting down fine bituminous coal before use for hand firing of boilers? J. P.

Wetting down fine coal before firing makes cleaner handling, permits of better spreading, stoking is accompanied by much less annoyance from back-draft and less combustible material is carried over into the combustion chamber of the furnace and less fuel drops through the grates. From moistening the fuel the tendency of fine coal to remain packed in spots of the fire is overcome, as the steam generated opens the mass, the coal is burned more uniformly and more completely and with fewer cracks or large holes in the fire. The principal disadvantages from the use of moist fuel are that the water content requires heat for its evaporation into steam which is discharged to the chimney as superheated steam at atmospheric pressure, and when much sulphur is present the condensate takes the form of a sulphurous acid, which is corrosive of steel stacks and ironwork in chimneys and smoke connections. However, the percentage of heat required for evaporation of this moisture is inconsiderable, and with good spreading of the fuel this loss generally will be much more than offset by the advantage of less excess air admitted to the furnace, due to more uniform distribution of draft passages through the fuel bed.

Evaporation from and at 212 Deg. F. Under Given Conditions

With a combined boiler and furnace efficiency of 70 per cent how many pounds of water at 212 deg. F. can be evaporated into steam, at the same temperature, by combustion of a pound of coal of the composition, 74 per cent carbon, 8 per cent hydrogen, 5 per cent oxygen and 13 per cent ash? E. C.

The heat liberated by perfect combustion of a solid compound or mixed fuel, is given by the formula,

$$\text{Number of B.t.u. per lb.} = 14{,}600\ C + 62{,}100\left(H - \frac{O}{8}\right) + 4{,}000\ S$$

where C = weight of carbon in 1 lb. of the fuel; H = weight of hydrogen; O = weight of oxygen; S = weight of sulphur.

By substituting the given percentages and neglecting S, the formula becomes

$$\text{B.t.u per lb.} = 14{,}600 \times 0.74 + 62{,}100\left(0.08 - \frac{0.05}{8}\right) = 15{,}384 \text{ B.t.u.}$$

Evaporation of a pound of water from and at 212 deg. F. requires the latent heat of evaporation at that temperature, which is 970.4 B.t.u.

Hence with perfect combustion and perfect boiler efficiency, one pound of the fuel would evaporate 15,384 ÷ 970.4 = 15.85 lb. of water per pound of the fuel.

With a combined furnace and boiler efficiency of 70 per cent the evaporation from and at 212 deg. F. would be 70 per cent of 15.85 = 11.1 of water per pound of the fuel.

Coal and Water per Kilowatt-Hour

The electrical output of our plant for 5 days' run was 6,086 kw.-hr., with a consumption of 26,010 lb. of coal costing $8 per ton and 293,880 lb. of water costing 0.05c. per cu.ft. How much coal and water was used per kilowatt-hour and what is the cost for coal and water per kilowatt-hour? M. D.

The coal used would be 26,010 ÷ 6,086 = 4.27 lb. per kw.-hr. At $8 per ton of 2,000 lb. the cost would be $8 ÷ 2,000 = $0.004 per lb.; hence the cost of coal was 4.27 × $0.004 = $0.01708 per kw.-hr.

The water used would be 293,880 ÷ 6,086 = 48.28 lb. per kw.-hr. At ordinary temperatures the weight of a cubic foot of water is about 62½ lb., and at 0.05c., or $0.0005 per cu.ft., the cost would be equivalent to $0.0005 ÷ 62.33 = $0.000008 per lb. Hence the cost for water would be 48.28 × $0.000008 = $0.000386 per kw.-hr., making the total cost $0.01708 + 0.000386 = $0.017466, or practically 1.75c. per kilowatt-hour.

Measurements of Indicator Diagrams by Ordinates

How does the ordinate method of measuring indicator diagrams compare with the accuracy attainable with a planimeter? R. C. A.

For determining the average height or m.e.p. of ordinary forms of diagrams, the results of measurements made by the method of ordinates may be equally as good, for all practical purposes, as when made with the planimeter, provided the operations are performed with the same skill and care, although measurement by the planimeter may be more rapid and more convenient from saving of the time required for locating the middle ordinates. In applying the method of ordinates, the commonest source of error is imperfect scaling of the heights of the middle ordinates for determining their average height. For that purpose the most accurate method is to transfer a summation of the ordinates to the straight-edge of a strip of paper. Then by the use of a rule, or scale, make a single measurement of the accumulated heights and divide this by the number of middle ordinates to obtain the average height.

Storage Space Per Ton of Coal

For storage of coal what number of cubic feet of space is required per ton. G. S.

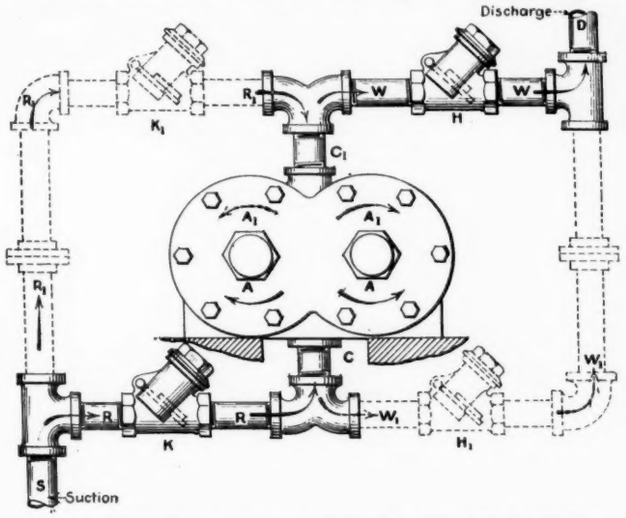
The weight per cubic foot of broken coal depends on the specific gravity of the coal, which varies with coals furnished from different localities and at different times from the same mine. It varies also with the size and uniformity of size and also depends on how much the coal is "shaken down" in bulk by transportation and method of handling. Hence there is considerable variation in the number of cubic feet per ton, and further confusion is likely to arise from misunderstanding whether the consideration is to be made of "short" tons of 2,000 lb. or "long" tons of 2,240 lb. The average weight of commercial sizes of broken American anthracite, shaken down in boxes holding 2 cu.ft., has been quoted as 53.4 lb. per cu.ft., and the average weight of Maryland and Pennsylvania bituminous coal as 52.8 lb. per cu. ft.; from which a "short" ton of anthracite would occupy about 37.5 cu.ft. and a "long" ton about 42 cu.ft. and a "short" ton of bituminous coal would occupy about 38 cu.ft. and a "long" ton about 42.5 cu.ft.

Arrangement of Check Valves for Reversible Rotary Pump

How are check valves connected with a rotary pump that operates in either direction of rotation? W. A. H.

When the direction of rotation is reversed, the suction inlet of the pump becomes the outlet for the discharge, and vice versa. As shown in the sketch, each side is connected to the main suction pipe *S* with a check valve opening toward the pump, and each side is connected also with the main discharge pipe *D* with a check valve opening toward the main discharge pipe *D*.

When rotation of the impellers is in direction of the arrows *AA*, the lower connection *C* becomes the suction inlet, with the check valve *K* opening for flow of suction



CONNECTIONS FOR REVERSIBLE ROTARY PUMP

water from *S* in the direction of the arrows *RR*, and check valve *H* is opened for discharge in direction of the arrows *WW*. With these directions of flow, check valve H_1 remains closed by the pressure of the atmosphere, or back pressure from *D;* the check valve K_1 remains closed by back pressure from the discharge outlet of connection C_1.

By rotation of the impellers in the direction indicated by the dotted arrows A_1, suction flow takes place in direction of the dotted arrows R_1R_1, and the discharge flow is in direction of the dotted arrows W_1W_1, with check valve *K* held closed by pressure from the pump discharge and check valve *H* held closed by atmospheric pressure or back pressure from the main discharge pipe *D*.

Heat of Combustion of Kerosene

What number of B.t.u. would be released in the combustion of one gallon of kerosene? F. E. B.

The amount of heat liberated depends on the perfection of the combustion. In theoretically perfect combustion of average kerosene there is liberation of about 20,000 B.t.u. per pound, the amount varying with the specific gravity of the oil. The specific gravity is about 0.82, and as the weight of a gallon would be 8.33 × 0.82 = 6.83 lb., the heat liberated in perfect combustion of the oil would be about 6.83 × 20,000 = 136,600 B.t.u. per gallon.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses.—Editor.]

Easy Lessons in Engineering

Losses Up the Stack

For a fuel containing no combustible except carbon, zero excess air would give 21 per cent CO_2 and 79 per cent N_2; 100 per cent excess air (twice the theoretical amount) would give 10½ per cent CO_2, 10½ per cent O_2 and 79 per cent N_2; while 200 per cent excess air (three times the theoretical amount) would give $\frac{1}{3} \times 21 =$ 7 per cent CO_2, 21 — 7 = 14 per cent O_2 and 79 per cent N_2.

The previous article also showed that for a hydrogen-free fuel completely burned, the flue loss expressed as a percentage of heat in the fuel is $0.02 \times \frac{21}{\text{per cent } CO_2} \times$ temperature difference, where 0.02 is the percentage loss per degree of temperature difference with no excess air and $\frac{21}{\text{per cent } CO_2}$ is the ratio of actual air to theoretical. In the form given, this formula is not exact where the fuel contains hydrogen. However, for moderate amounts of hydrogen the only change needed is in the second item, which must be changed to represent the ratio of air supplied to that actually used under the new conditions. Where hydrogen is present, it burns to H_2O (water), which does not appear in the flue-gas analysis. The amount so disappearing is, for a given fuel, a definite fraction of the CO_2, averaging about 0.1 the CO_2 for anthracite coal and 0.15 for bituminous. So if 21 represents the total air supplied, the air "burned" will approximate 1.10 CO_2 for anthracite and 1.15 CO_2 for bituminous coal.

As an example, let us find the flue loss for an average bituminous coal if the CO_2 is 11 per cent, the flue temperature 540 and the room temperature 70. Then the temperature difference = 540 — 70 = 470 deg. The ratio of actual air to theoretical $= \frac{21}{1.15 \times 11} = \frac{21}{12.6} = 1.67$. Therefore the flue loss $= 0.02 \times 470 \times 1.67 = 9.4 \times 1.67 = 15.7$ per cent. This should be called 16 per cent, as the accuracy of the method does not warrant splitting per cents.

The same method can be used for fuel oil by multiplying the percentage of CO_2 by 1.4 to represent the theoretical air. So for fuel oil 12 per cent CO_2 would indicate $\frac{21}{12 \times 1.4} = \frac{21}{16.8} = 1.25$ as the ratio of actual air to theoretical.

It should be noted that the greater the proportion of hydrogen in a fuel the less is the percentage of CO_2 for the same percentage of excess air. A CO_2 percentage of 13 per cent with fuel oil is a better performance, as far as excess air is concerned, than 13 per cent with coal, although it is obtained as frequently because of the better control possible with fuel oil.

Two important flue losses have not yet been considered. The first is the heat required to evaporate moisture, that originally in the coal and—more important—that formed by the burning of hydrogen. This loss can be figured, allowing about 1,300 B.t.u. per pound of moisture, but it is hardly worth while in every day operation, because after the fuel has once been purchased this loss is unavoidable.

The loss due to incomplete combustion may be computed by comparing the percentages of CO and CO_2 in the flue gas. For example, suppose that with a fuel free from hydrogen the flue gas contains 12 per cent of CO_2 and 1 per cent of CO. That is, the volume of CO is $\frac{1}{12}$ the volume of CO_2. Since equal volume of all gases (at same temperature and measure) have the same number of molecules, there are $\frac{1}{12}$ as many CO molecules as CO_2 molecules. A molecule of CO contains the same amount of carbon as a molecule of CO_2, so the analysis shows that $\frac{1}{12}$ as much carbon burns to CO as to CO_2. That is, of 13 parts of carbon one part burns to CO and 12 to CO_2. The general relationship may be expressed by the formula,

$$\textit{Fraction of carbon burning to CO} = \frac{CO}{CO + CO_2}$$

Now each pound of carbon burning to CO_2 gives off 14,600 B.t.u., but only 4,450 when burning to CO. So for every pound of carbon that burns to CO 14,600 — 4,450 = 10,150 B.t.u. are wasted. This is $\frac{10,150}{14,600} = 0.70$, or 70 per cent of the heat in the portion of the carbon so burned. Then the actual percentage loss due to incomplete combustion for a hydrogen-free fuel is $\frac{CO}{CO + CO_2} \times 70$. Applying this to the case just considered where the CO_2 = 12 per cent and the CO = 1 per cent, the percentage loss due to incomplete combustion is $\frac{1}{1 + 12} \times 70 = \frac{70}{13} = 5.4$ per cent. This shows that even one per cent of CO causes a serious loss. The chief purpose of these CO calculations is to emphasize the importance of even a small amount of CO. In practical operation it is best not to spend much time figuring CO losses, but rather to look upon CO, or at least any CO over ¼ to ½ per cent as a red flag. If the CO gets higher, it is better to take steps to cut it down than to spend time figuring the exact amount of the loss. As far as efficiency is concerned, the best operation is obtained by carrying the CO_2 as high as possible without running into more than a trace of CO. Going much higher or lower means a large loss of fuel. It is right here that many steam-power plants could save from 10 to 25 per cent of their yearly fuel bill. Nothing pays better than watching the flue gases.

Iron and Steel Electrical Engineers Hold Seventeenth Annual Convention

DURING five days, Sept. 24 to 28, the Association of Iron and Steel Electrical Engineers held its most successful convention in the Broadway Auditorium, Buffalo, N. Y. One of the big features of the convention was the Iron and Steel Exposition, at which 120 manufacturers of steel-mill electrical and mechanical machinery assembled equipment valued at one million dollars. A number of these exhibits consisted of demonstrations of the equipment. One of the best examples of this was an 800-lb. electric melting furnace forming part of an electrically equipped foundry that was in operation producing commercial products during the entire convention. There was a total membership registration of 1,176, among whom were 15 of the 17 past presidents of the association. It is estimated that approximately 20,000 people visited the exhibition.

At the banquet which was held in the grand ball room of the New Statler Hotel on Thursday evening, the following names were announced as the officers of the Association for the next year: President, R. S. Shoemaker, Supt. of Maintenance Dept., American Rolling Mills Co., Middletown, Ohio; first vice-president, A. C. Cummins, Elec. Supt., Carnegie Steel Co., Duquesne, Pa.; second vice-president, George H. Schaeffer, Elec. Supt., Carpenter Steel Co., Reading Pa.; treasurer, (re-elected) James Farrington, Elec. Supt., LaBelle Iron Works, Steubenville, Ohio; Secretary, (re-elected) John F. Kelley, Empire Bldg., Pittsburgh, Pa.; board of directors—Walter C. Kennedy, Operating Engineer, Worth Steel Co., Claymont, Del.; H. E. Davis, Elec. Eng., Interstate Iron and Steel Co., East Side Station, Chicago, Ill.; A. F. Jones, Elec. Eng., Champion Machine and Forging Co., Cleveland, Ohio; A. F. Elliott, Elec. Eng., Sloss, Sheffield Steel and Iron Co., Birmingham, Ala.; F. W. Cramer, Engineer of Tests, Cambria Steel Co., Johnstown, Pa.

On Monday afternoon the first technical session was held, at which was presented the report of the various technical committees. In this year's committee report, by Walter C. Kennedy, chairman, is given a list of 76 motors for main-roll drives in steel mills and 6-in. copper and brass mills, which have been installed or have been placed on order since the report of last year.

Among these drives are 8 motors that have replaced steam engines varying in size from 500 to 7,000 hp. Among the reasons given for the electric motors replacing steam engines for main rolls drives. The increasing cost of coal and therefore steam; increasing availability of reliable purchased power; developments in gear drive. It is stated in the report that operators are realizing more and more that they cannot afford to keep these old steam engines in operation. They are inefficient in their use of steam and require constant attendance and maintenance. It is not an uncommon thing for the saving in cost of attendance, maintenance and repairs to more than pay for the fixed charges on the electrical installation, leaving a saving in power consumed as profit.

Another feature of the electric drive is the extent to which gears are being used. On six of the drives listed gears are used between the motor and the rolls. These drives consist of three 3,000-hp., two 5,000-hp. and one 6,250-hp. motors.

Automatic Engine Stops Specifications Accepted

At the Monday afternoon meeting the General Specifications for Construction and Installation of Automatic Engine Stops were accepted as recommended by the safety committee and presented by Walter Greenwood, chairman. These specifications are to be known as the Association of Iron and Steel Electrical Engineers Specifications and will be published in full in an early issue.

In a paper, "Standardization of Engine Stops," Mr. Greenwood emphasized the importance of automatic engine stops on both turbines and reciprocating engines by giving a number of examples of how serious accidents have occurred to this class of equipment, due to overspeed, the various combinations possible in automatic engine stops are given and attention is also called to the various ways that flywheels may be wrecked. An abstract of this paper will appear in an early issue.

The report of the special bearing committee, by D. M. Petty, chairman, which was presented at the Tuesday morning session, was the center of much interest. Although this committee during the last year made a careful study of applying roller and ball bearings to motors, no definite decisions have been made. It is stated in the report that among users of motors there is a relatively small class who have used ball bearings in motors, a vast majority of whom are enthusiastic over the results obtained. They have had some bearing failures, but have been able to explain these satisfactorily and definitely fix the cause as being due to improper mounting, improper size of bearings, grounded armatures, improper lubrication, both in quality and quantity.

Considerable of the discussion on this report centered around the number and size of bearings that should be standardized on for motors in sizes of 1 to 100 hp. and the possibilities of making these standards applicable to both the mill-type and general-service motor. A range of 15 size of ball bearing was suggested for motors ranging in capacity of 1 to 100 hp., but no definite action was taken in the matter other than that this year's committee is to co-operate with those interested, toward working out satisfactory standards.

It was pointed out that one of the chief objects of using ball bearings was to keep the oil in the bearing and the dirt out. In this direction the manufacturers of motors using sleeve bearings had neglected to give proper attention to the design of the sleeve bearing and there was no apparent reason why a sleeve bearing could not be made as oil and dirt tight as a ball or roller bearing. It was felt by some that there was a possibility of going too far in the use of ball and roller bearings, that the use of these bearings was still in the experimental period of standardization for motors and should be approached cautiously.

D. M. Petty, in closing the discussion, said he wished to see the question of standardization of ball and roller bearings settled so that his company could go ahead and change over its motors from the sleeve type of bearings. He called attention to having examined a number of motors and found that the change could be made at a relatively small cost.

Motor Operated Centrifugal Pumps

A paper, "Motor Operated Centrifugal Pumps in Steel Plants," by B. A. Cornwell, was the center of considerable interest. The paper gives test data on large motor-operated centrifugal pumps and draws a comparison between the cost of pumping water with motor-driven pumps and geared steam-turbine driven pumps. An abstract of this paper will appear in an early issue.

In the discussion, the danger of overloading the motor driving the pump was emphasized, due to reduced head. It was pointed out that using a 40-deg. motor with a two-hour 25 per cent overload guarantee made it possible to motor the pump closely without any danger of seriously overloading in case the head on the pump was less than estimated. However, with the 50-deg. motor without sustained overload capacity trouble has been experienced with motors burning out and it was necessary to choose motors considerably larger than actually required, so as to have some reserve capacity to take care of contingencies arising from reduced head on the pump. The question was raised regarding the proposed 40-deg. motor without any overload guarantee being able to meet the condition prevailing with centrifugal-pump installation without exceeding the safe temperature limit of 55 deg. rise. The discussion on this question brought out that it would require 15 to 20 per cent overload on the motor to cause 15 deg. rise above the rated 40 deg., depending on the size and characteristics of the motor.

At the Tuesday afternoon technical session, two papers were presented: "Single-Bucket Blast-Furnace Skip-Hoist Characteristics," by A. R. Leavitt and A. C. Cummins; and "A System of Coal and Ore Bridge Traverse Control for Protection Against Wind and Skewage Hazards of Skew-Type Direct-Current Bridges," by P. R. Canney. The latter paper outlines the hazard that an ore or coal bridge is subjected to and the limitation of the protection afforded by the average controller used on these bridges. The author points out that, except for the limit switches, no arrangement has been supplied in the controllers generally used for protection against the operator's carelessness, lack of judgment or mistakes. In order to eliminate as far as possible this hazard, as well as to provide against as many as possible of the other dangers, a system of control has been developed by C. O. Burton, Assist. Elec. Eng., Minnesota Steel Co. This control makes use of three separate but mutually interconnected and interlocked protective devices or systems in connection with the ordinary braking and locking equipment used on up-to-date bridges. These devices are an electrically-operated anemometer, a special skew-limiting and correcting controller and a set of improved remote-control track sanders. The anemometer is used to warn and protect against operation of the traverse motor in dangerous winds. In case the bridge is subjected to dangerous wind velocities or is skewed to a dangerous position, operation is automatically taken out of control of the operator and the bridge is automatically brought to a safe position.

Wednesday morning and afternoon technical sessions were devoted to presenting and discussing papers on "The Complete Electrification of the Foundry Industry," by L. W. Egan; "Electric Furnace Phenomena," by C. T. Moore, and "Liquid Slip Regulators or Rheostats," by D. M. Petty.

Economical Use of Fuel in Steel Plants

In a paper, "Economical Use of Fuel in Steel Plants" by H. C. Siebert, the author gave a detailed analysis of the ways that fuels are now used and the efficiency obtained in steel plants. These results were compared with what might be obtained by proper methods of operation. Owing to the use of beehive coke ovens instead of the more improved types, 7,000,000 tons of coal is being wasted per year in the iron and steel industry. The author pointed out that he did not represent extreme cases when he placed the average efficiency of the steel-mill boiler plant at 50 per cent, where it should be 80 per cent, and the stoves for heating the blast-furnace air were operated as inefficiently as the boiler. By efficient methods of operation it is possible to produce from the excess blast-furnace gas double the amount of power that is now being obtained under average conditions.

In the discussion, among the suggestions made for utilizing excess blast-furnace gas was blowing gas producers. To prevent clinkering in the producer, one company has found that blowing the producer six minutes with air and two minutes with blast-furnace gas gives entire satisfaction.

Dr. D. S. Jacobus corroborated the statements of the author of the paper by saying that 50 per cent and 80 per cent boiler efficiency was about the true story in the steel mills. It was possible to obtain 80 per cent efficiency with properly designed furnaces and good equipment.

J. B. Crane pointed out that the question of fuel economy in the steel plant was one of how much it was going to cost to get and maintain the high efficiency talked about. The speaker told of an installation of four 9,000-sq.ft. boilers being made in Europe that are to be operated on the waste heat from coke ovens by recirculating the air used in extinguishing the coke.

Thomas A. Marsh, in a paper, "Tempering of Coal," gave the results of tests made by moistening coal before burning. The author points out that on first consideration it would seem that adding a non-combustible to fuel is diametrically opposed to the attainment of higher efficiency or capacity but observation of operating conditions and results convince that improved results do attend the moistening of certain coals.

Among these advantages are: Decreased sifting of coal; fewer holes in fuel bed, hence less excess air; higher combustion rate with given draft; improved quality of ash; better ignition with traveling grate.

These are items of major importance which have been observed by the author and others on actual evaporative tests. In collecting data on this subject, the author sent out about 50 questionnaires to combustion engineers and power-plant operators. Practically all west of Pittsburgh reported definite advantage in tempering coal. With Eastern coals the reverse was reported. Few claimed advantages for moistened coal with underfeed stokers. Practically all claimed the foregoing advantages with traveling grates with either natural or forced draft.

From these investigation, reports to questionnaires and discussion the following conclusions are drawn:

1. Moisture can be added to some coals to definite advantage. This applies to Western bituminous coals (Pittsburgh and west).
2. Coke braize, anthracite and dock screenings burn better when slightly dampened to prevent siftings and blowing of fuel bed.
3. The effects of moistening are more pronounced on traveling-grate stokers so far as combustion results are concerned.
4. The amount of moisture to be added will average about 3 per cent, which is equivalent to $\frac{3}{10}$ of 1 per cent decrease in net evaporative effect from the coal.
5. The advantages obtained from tempering coal more than offset the slight decrease in net value of the coal.
6. Steam and hot water temper coal quickly and well, but should be used only when a study of gain and loss has been made.
7. Tempering requires time. Cold water added in stoker hoppers does not temper coal.
8. Moisture should be added with discretion and under guidance of some tests to indicate the amounts and effect of various items of the heat balance.

High-Pressure Steam Boilers

At the Thursday afternoon technical session Dr. D. S. Jacobus presented a paper on "High-Pressure Steam Boilers," in which he reviewed the work of the pioneers in this class of equipment and then described the new type of boiler developed by his company for pressures up to 1,200 lb. An abstract of the paper will appear in an early issue. In presenting his paper, the author said it had been found advisable to control the reheating of the steam, and to do this the reheater had been placed above the upper deck of tubes and arranged with a damper so that the gases passing over the reheater could be controlled. In answer to a question Dr. Jacobus said that the new high-pressure boiler had slightly less water in it than a 300-lb. boiler of the same capacity, but the former had a great deal more water than a marine boiler of the same capacity.

W. P. Chandler drew a comparison between the boiler designed for 1,200-lb. pressure and the Benson process and was of the opinion that the high-pressure boiler had a number of advantages over the latter.

H. B. Oatley said that the placing of the reheater above the top deck of the tubes, so that the reheating could be controlled, removed an objection he had to the original design of the boiler. It was the speaker's opinion that steam drums should be 30 in. in diameter or less. He agreed with Dr. Jacobus that it was advisable to make the drums seamless.

Other papers presented at the Thursday afternoon session were "Boiler Troubles from the Operating Man's Standpoint," by Carl J. Smith, and "Surface Combustion and its Applications," by W. N. Hepburn. An abstract of the former will appear in an early issue. Mr. Hepburn's paper deals with surface combustion as applied to industrial applications. The last technical session was held on Friday morning, at which P. T. Vanderwaart presented a paper on "Systematizing the Work of an Electrical-Engineering Division," and F. O. Schnure a paper on "Electric Transportation."

Boundary Lubrication Theory and Oil Grooves

The results of researches indicate that the Reynolds theory of lubrication is insufficient. According to the hydro-dynamical view, the nature of the lubricant is immaterial, since its viscosity alone affects the results. Without varying the viscosity of a lubricant to any appreciable extent, however, it has been found possible to vary the coefficient of friction over a wide range. This indicates that other conditions affect friction of lubrication than those included in the Reynolds theory. It was also brought out that oil grooves played an important part in lubricating a bearing, in a lecture entitled "The Nature of Lubrication in Engineering Practice," delivered to the International Air Congress, in London, June 29, 1923, by T. E. Stanton.

Dr. Stanton stated that during the last five years considerable modification has taken place in the views held by engineers of the action between lubricated surfaces of the machines in which they were interested. It appears that the acceptance by engineers that the value of oils, as lubricants, depends solely on their viscosity, as according to the Reynolds theory, has not been at all general. Since the days of the last century, engineers of wide experience have been fully alive to the fact that animal and vegetable oils were superior, as lubricants, to mineral oils of the same viscosity, on account of some characteristics for which there was no definite test.

The characteristic which is not accounted for is described as "boundary" lubrication. This relation is known as Amonton's, which holds that friction for a given normal pressure between surfaces is independent of relative speed and area of contact. It is now recognized that if solid surfaces have an "adsorbed" layer of lubricant of only 1 molecule in thickness, they can slide over each other with comparatively small frictional resistance. Adsorption is dependent upon the chemical constitution of the lubricant, so that the greater the work done in the process of adsorption the less the frictional resistance of the surface to sliding. Acids, alcohol and esters are more strongly adsorbed by water than are paraffins, and it is found that the former are better lubricants than the latter. By adsorption is meant the quality of a body of attaching a thin film of another substance to its exterior surface. W. B. Hardy has shown that Amonton's law is strictly followed where boundary lubrication can be produced.

Tests of a worm and gear indicated that animal and vegetable oils were greatly superior to mineral oil, in regard to the temperature at which the gear could be run without serious increase in friction. This lubrication approaches the boundary type. Bearing friction was measured by a shaft given a rocking motion by means of a pendulum. By carefully observing the effect of friction on the oscillations, it was found that 17 per cent reduction in the coefficient of friction was obtained by the addition of as little as 1 per cent of organic acid to the heavy mineral oils used for lubricants. The viscosity of the lubricant was practically unchanged, showing that the difference in friction was due to other causes than that of viscosity, so that other conditions besides those of the Reynolds theory were responsible. Both shaft and journal contained oil grooves in this test.

Another test to determine the effect of oil grooves was made with and without such grooves. It was found that the friction in an ungrooved surface was 15 per cent higher than with a grooved surface, using castor oil as lubricant.

Pulverized Fuel for Large Boilers

In a paper recently delivered before the Western Pennsylvania Engineering Society, J. C. Hobbs, manager of the Alleghany County Heating Co., and L. W. Heller, superintendent of Brunots Island Plant, Pittsburgh, gave the results of tests on a powered-fuel installation at the Brunots Island Plant. These tests were made on a stirling-type boiler having 8,220 sq.ft. of heating surface, to which was attached a 180-sq.ft. water screen. During the first test the boiler was provided with a 255-sq.ft. superheater. For the succeeding tests this was replaced with a much larger one, having 1,031 sq.ft. of surface. At the same time the baffling was changed to give four effective passes instead of three.

A special furnace was built with large combustion chamber and air-cooled walls. The pulverizer, or milling plant, consisted of one 6-ton 6-roll mill, together with exhauster fan, separators and the usual piping.

From the results of these tests curves were plotted for various percentages of CO_2, showing the variation of over-all[1] efficiency, stack temperature and superheat with the per cent rating. Confining the discussion to the second set of tests, using the four-pass baffles and the larger superheater, the results may be summarized as follows:

For all percentages of CO_2 the over-all efficiency reached a maximum a little above rating and then dropped off more and more rapidly as the load increased. Curves were drawn for CO_2 percentages of 8, 10, 12, 14 and 16 per cent, but only the extreme curves for 8 and 16 per cent will be considered here. The over-all efficiency with 16 per cent CO_2 was 84 per cent at rating and 81 per cent at 250 per cent of rating, while with 8 per cent CO_2 the efficiency was 82 per cent at rating and 75 per cent at 250 per cent of rating.

The curves show strikingly that the flue temperature rises as the rating increases or the CO_2 decreases. For example, at 100 per cent of rating the flue temperature is 425 deg. for 16 per cent CO_2 and 450 for 8 per cent, while at 200 per cent rating the stack temperature is 490 deg. for 16 per cent CO_2 and 560 for 8 per cent. This clearly shows that the high CO_2 has a double value, in that it not only decreases the amount of excess air, but cuts down the flue temperature.

These are the more or less well-known advantages of high CO_2. On the other side of the ledger must be entered not only the more rapid destruction of the refractories when the excess air is cut down to the limit, but also a reduction in the degree of superheat. For example, when operating at rating, an increase in CO_2 from 8 per cent to 16 per cent reduced the superheat from 132 deg. to 100 deg. The corresponding figures at 250 per cent of rating were 170 deg. and 130 deg.

The power required for grinding and blowing ranged from 19 kw.-hr. per ton at rating to 17 kw.-hr. at 250 per cent of rating. Of this total the power consumed for grinding coal remained constant at 14 kw.-hr. per ton, while that consumed by the blower varied from 5 kw.-hr. per ton at rating to 3 kw.-hr. at 250 per cent of rating.

The writers expressed the opinion that the increased use of pulverized fuel would lead to the general adoption of furnaces cooled by air or water. In their opinion the water-cooled furnaces had greater possibilities. The general adoption of air- or water-cooled furnaces, together with powdered coal, would make it possible to operate with a very small percentage of excess air. This would lead not only to higher efficiency, but also to a greater rate of combustion per cubic foot of furnace volume. It would also increase the developed boiler capacity that could be handled by a given stack and greatly reduce the draft drop through the boiler when operating at a given rating.

Storage of Bituminous Coal—A Correction

In the article, "The Storage of Bituminous Coal," by W. L. Abbott, published in the Sept. 25 issue of *Power*, which was a reprint from a paper given before the N.A.S.E. at its Buffalo Convention, there was an error, due to transcription of the notes, on page 514. The paragraph reads, in part, as follows: "A round lump of coal one inch in diameter has a superficial area of a little more than three square inches. This same lump ground to one hundred pieces of equal sizes will have a superficial area of 300 sq.in. and the amount of heating will be increased one hundred fold." It should read: "This same lump of coal ground to pieces each one one-hundredth of an inch in diameter will have a superficial area of over 300 sq.in."

[1]The term "over-all efficiency" is here used to mean combined furnace and boiler efficiency *not* including power consumed by auxiliaries.

News in the Field of Power

Oil Engines Will Supersede Steam Engines at Sea Say British Experts*

The Institution of Mechanical Engineers Is Arranging To Promote More Efficient Mechanical Engineering Education in England

PREDOMINANCE of steam as a means of propulsion at sea will not be maintained many years more, in the opinion of some of the best-informed mechanical engineers and naval architects in Great Britain. The internal-combustion engine, they believe, is destined to be used in increasing numbers from this time forward.

Owing to the great interest in power plants for ships, the Institution of Mechanical Engineers and the Institution of Naval Architects have joined in forming a special committee to conduct marine oil-engine trials. The committee is to obtain accurate scientific information as to the efficiency and economy with which these engines can be operated and to ascertain with definiteness the amount of vessel control which is possible when internal-combustion engines are used.

Various manufacturers of internal-combustion marine engines are cooperating with the committee, and opportunities will be had to test, in actual service at sea, the principal six types of engines.

The committee is composed of seventeen members, including the Admiralty representative and two representatives of the Institute of Marine Engineers. The engineers on the committee have been chosen with great care so that the different branches of the profession are represented.

The tests are not to be confined to one ship. The experiments at sea will include runs on a measured mile course, during which observations will be made of the horsepower transmitted by the propeller shaft and of the propeller thrust. It is expected that these observations will yield, on analysis, valuable information concerning the effect of hull shape and propeller efficiency. There will be repeated stopping, starting and reversing at different speeds. Runs will be made at the lowest possible speed. Auxiliary engine and accessories will be tested, as well as other maneuvering and control trials. In this way it is hoped to establish much more accurately than is known at present the utility of an internal-combustion engine ship as a maneuvering agent.

The tests ashore will be of the general character of maker's tests, but will be carried out more exhaustively. Progressive test-bed trials, including fuel consumption, indicated and brake horsepower, together with observations of the exhaust gases and cooling water, will enable thermodynamic and other deductions to be drawn as to the performance of the engine itself as a motive-power unit.

Great importance is attached by Brig.-Gen. Magnus Mowat, the secretary of the Institution of Mechanical Engineers, to the work being done by the institution to promote mechanical engineering education and to make such technical training available to properly qualified young men. The object is, he says, "to link in closer and more harmonious union theory and practice in mechanical engineering." He believes this plan squares with the object of the organization as announced by George Stephenson, its founder; namely, "the promotion of the science and practice of mechanical engineering in all of its branches."

Arrangements have been made with the leading technical schools of the country for part-time courses of study, largely in evening classes for specialized attention to mechanical engineering education. Beneficiaries of the arrangement enter these special classes at the age of sixteen years. Subsequently, the more advanced courses are to be taken at other institutions. Certificates are granted when these prescribed courses of study have been completed successfully. An ordinary diploma is granted for a further full daytime course at specified institutions. A higher diploma is granted for those who take the course at any one of these four designated technical colleges.

The certificates and diplomas are signed by the president of the Institution of Mechanical Engineers.

The 8,000 members of the institution are expected to give priority to the holders of these credentials in the selection of their own employees. Later, these young men will qualify for membership in the institution, when it is expected they will be much interested in perpetuating the plan.

*[This article, and several others which will follow, is based on the personal investigations of Paul Wooton, *Power's* Washington correspondent, who has just returned from England and France, where he covered several assignments for the McGraw-Hill Engineering Publications.—EDITOR.]

Gorgas Plant Sold to the Alabama Power Company

The Secretary of War announced on Sept. 24, the sale of the Warrior extension and appurtenances at Gorgas, and power transmission line from the plant to Sheffield for $3,472,487.25 cash and the delivery of the deed.

Henry Ford was notified of the approaching sale, and although he had asked for an extension of time, or until Nov. 1, for his reply as to whether the unit was essential to the successful operation of Muscle Shoals, this extension was not given. Army engineers say that the Gorgas plant is not essential to the successful operation of Muscle Shoals, having been originally only a war measure.

A.S.M.E. Announces Officers

The committee of tellers have finished the count of ballots cast for officers for the Society for the following year and announce the result as follows: President, Fred R. Low, Editor *Power*, New York City; vice-presidents, George I. Rockwood, president and treasurer, Rockwood Sprinkler Co., Worcester, Mass.; H. Birchard Taylor, vice-president, William Cramp & Sons Ship & Engine Building Co., Philadelphia; W. J. Sando, consulting engineer, Milwaukee, Wis.; managers, E. C. Eastwood, professor of mechanical engineering, University of Washington, Seattle, Wash.; F. A. Scott, president The Warner & Swasey Co., Cleveland, Ohio; E. R. Fish, vice-president, The Heine Boiler Co., St. Louis, Mo.; treasurer, W. H. Wiley, president John Wiley & Sons, Inc., New York City.

Arizona Presents New Power Plan for Colorado River

A plan for the development of the power resources in the Arizona sector of the Colorado River by the state was laid before the Federal Power Commission Sept. 24. Arizona was represented by Governor Hunt and a committee of nine. State Senator Elliott acting as spokesman for the committee, denounced the Colorado River compact as unfair to Arizona. He said Arizona was asked to agree but got nothing in return. He intimated that federal officials had attempted to coerce Arizona into signing. Arizona is not objecting to granting the Girand license and the development of the power at Diamond Creek by the copper companies, it was explained.

After listening, on Sept. 25, to the arguments of the upper states of the Colorado River basin, the Federal Power Commission adjourned its hearing with-

out rendering any decision other than to state that no cognizance of the Arizona State development proposal would be possible until full and definite details are furnished as to financial arrangements and to every other step necessary to the bringing of the power into use.

No meeting of the commission will be held until Oct. 10, so that the decision as to what will be done in the matter of the Girand license for the development of the Diamond Creek project will be delayed until that time at least.

While no encouragement was held out by the commission to the anti-pact faction in Arizona, it is quite apparent that its position was strengthened. The scheme of state development, while it is admittedly nebulous, nevertheless gives the anti-pact forces a talking point and an issue with which they can go before the people.

Coal Commission Recommends Supervision of the Coal Industry

Final Report Suggests That a Special Division of the Interstate Commerce Commission Take Charge of the Coal Industry

"SELF regulation under Governmental supervision" sums up the remedial recommendations in the final report of the United States Coal Commission. Throughout the report emphasis is put on the conviction that the industry can reform itself from within. While some legislation will be required to carry out the suggestions of the Commission, the remedies proposed are largely non-legislative in character.

Monopoly is cited as the fundamental evil in the anthracite industry. While no hope is held out for material reductions in anthracite price, the Commission believes that wholesome results will follow the imposition of a graduated tax on royalties and differential profits.

Over-development, irregularity of operation and consequent enforced idleness of miners and of invested capital constitute the Commission's opinion as to the chief evils in the bituminous industry. Very definite control over those evils can be exercised by the Interstate Commerce Commission, under existing laws, the Commission points out, by its power to regulate commerce among the several states and its power to regulate transportation; regulation of commerce in coal among the several states involves the right to know the cost of production, whether the investment on which a return is claimed is fairly estimated or inflated and what profits are made by owner, operator and dealer and what are the earnings and working conditions of miners.

A special division to be created in the Interstate Commerce Commission, is suggested, as the agency to exercise the necessary administrative and quasi-judicial functions required for the coal industry, with the co-operation, for fact-finding and regulation, of the Geological Survey and other bureaus.

The Commission recommends the use of federal power both to protect the public and to promote the normal development of this great basic industry. The public includes investors in coal lands and properties, coal operators and miners, sales agents and retail dealers as well as industrial and domestic consumers.

The Commission believes that the industry will not suffer in the slightest degree by abandoning secrecy and states that facts rather than rumor, information rather than prejudice, be the guide to coal service.

General recommendations for government action include the greater use of river transportation; that the long haul of coal be no longer encouraged by favoring rates; the limiting of marketing areas by the adjustment of freight rates; the consolidation, grouping or pooling of bituminous operations.

Recommendations for action within the industry include: Taxation of royalties and excess profits; management for effective service to the public rather than exclusively for monetary return; the payment of fair wages; better engineering in mines; co-operation for mine safety between operators and miners; the profiting by the example of the British wage agreement, whereby operators and miners share the profits of the business; betterment of living conditions for employees, which includes suggestions for both miners and operators; better regulation of wage rates to be developed by both operators and miners; national agreement in collective bargaining; objections to the check-off especially in regard to fines and assessments.

Consumers are advised as to their duties in regard to coal storage, about the advantages to the whole industry by the purchase of coal on contract, the suggestion that more study be given to the best methods of getting the heat units out of the coal consumed and the need for more fuel engineers.

Licensing retail coal dealers, co-operative associations, for buying, and municipal fuel yards are suggested as possible community actions, which are considered more democratic and desirable than the distribution of coal by the federal government.

An executive order has been issued by the President providing that the records, files and property of the United States Coal Commission be transferred to the Department of the Interior. The Secretary of the Interior is designated as the custodian of the files and the Director of the Geological Survey is designated to perform the administrative duties incident to the closing of the work of the Commission.

Lease On Cahokia Plant Denied by Missouri P.S. Commission

The Missouri Public Service Commission on Sept. 12, denied permission to the Union Electric Light & Power Co. to lease the Cahokia power plant now nearing completion on the east bank of the Mississippi River below East St. Louis, Ill., for a term of thirty-five years. The lease called for an annual payment equal to 8 per cent return on the invested capital and 2.8 per cent for depreciation.

The commission held that 8 per cent was too high a return, to guarantee over so long a period, on property constructed during a period of high prices. Commissioner Bean, who wrote the opinion, pointed out that the United States Supreme Court in the Bell Telephone case, recently decided, held the public is entitled to the benefit of any reduction in material costs in the future when cost of replacements may be lower than the original cost of construction.

O. C. Merrill Reports Progress of World Power Conference

Members of the Executive Committee on American Participation in the World Power Conference met, at the A.S.M.E. headquarters in New York City, on Sept. 11, to hear the report of the general chairman, O. C. Merrill, who had recently returned from conferences with representatives of other national committees co-operating in the World Power Conference.

The preliminary program as published in the Aug. 28 issue of *Power* was adopted. Stress was laid, Mr. Merrill reported, on the desirability of dealing in the first power conference with the general aspects of the power problem rather than with discussion of details. Arrangements have been made for several rooms in the Exposition Building of the British Empire Exposition at Wembley Park for the sessions of the Conference and a clubhouse will be available for the use of delegates. It is expected that arrangements will be made for trips through Western Europe to see special points of engineering interest, and it appears probable that two trips concurrently, one into Norway and Sweden and the other into France, Italy and Switzerland, will be made.

The National Research Council designated the following individuals as its representatives on the General Committee: E. B. Craft, Western Electric Co.; Gano Dunn, J. G. White Engineering Co.; R. A. Millikan, California Institute of Technology. The Southern Appalachian Power Conference designated Col. Joseph Hyde Pratt, Director, North Carolina Geological and Economic Survey; H. L. Wills, Georgia Railway, Light & Power Co.; Col. Edgar Jadwin, War Department, as their representatives.

The National Association of Manufacturers of the United States of America suggested the desirability of its

membership on the General Committee, and it was voted that the association be entitled to name three delegates.

Code on Heating and Ventilation Being Prepared

The committee appointed to formulate "A Code of Minimum Requirements for the Heating and Ventilation of Buildings," held a meeting recently in New York City, at which steps were taken toward the preparation of a tentative code which will be presented to the American Society of Heating and Ventilating Engineers at their annual meeting in January for adoption. The following, sub-chairmen of technical committees, are members of this committee: F. Paul Anderson, E. Vernon Hill, F. R. Still, A. C. Willard, D. D. Kimball, L. C. Soule, J. F. McIntire, J. D. Hoffman, J. R. McColl, J. A. Donnelly, W. S. Timmis, C. A. Booth, W. H. Carrier, Perry West, Ralph Collamore.

Bureau of Standards Explosion Due to Leak

The committee appointed by Dr. Burgess at Mr. Hoover's request to investigate the cause of the explosion and fire in the Dynamometer Laboratory of the Bureau of Standards on Sept. 20, 1923 made a detailed examination of the scene of the explosion, received statements from all available witnesses and, after consideration of all the evidence, presented the following report:

The explosion was caused by the ignition of a mixture of gasoline vapor and air in the altitude chamber. The Board believes that the presence of the gasoline vapor in the chamber was due either to a leak in the feed line leading to the carburetor of the engine or to a leak from the carburetor due to the sticking of the float mechanism. This conclusion is supported by a remark made by one of the members of the testing staff an instant before the explosion, to the effect that the gasoline readings which he was taking indicated the presence of a leak.

The condition of the set-up following the fire is such that it is not possible to establish which one of the above causes occasioned the leak. Since it is known that only three gallons of gasoline had been drawn for the test, that the engine had been running from about 11 a.m. to 12 m. with the chamber open, that the chamber was closed at about 12:30 for the purpose of running at a lower temperature, and that the engine had been operated from about 1 to 2 p.m. with the chamber closed, it is believed that not more than a quart of gasoline could have escaped into the chamber. This amount, however, if vaporized, would have been sufficient to account for the energy of the explosion.

The probable source of the ignition was a backfire through the carburetor. Support to this conclusion is given by the statement of one of the survivors that he heard the engine backfire immediately before the explosion.

The explosion threw out of the chamber a closed apparatus containing about ten gallons of heavy lubricating oil and about five gallons of toluol, breaking the pipe connections and thus releasing part of the contents, which furnished additional fuel for the fire which followed.

Special mention should be made of the action of C. M. Smith, engineer in charge of the ammonia plant, who, after being blown out of the building and badly cut about the head, returned to the wrecked chamber and shut off two ammonia valves, and then went to the refrigerating plant in the basement and operated it to pump the ammonia out of the coils in the wrecked chamber. This action may have prevented further loss of life and the destruction of the entire building by fire.

The dead are: Logan L. Lauer, assistant physicist; Urban J. Cook, machinist; Stephen M. Lee, mechanical engineer; J. E. Kendig, assistant electrical engineer. Among the injured Herbert K. Cummings, an associate physicist, continues in a critical condition.

DUDLEY J. KIMBALL

Dudley J. Kimball Elected Vice-President N. A. S. E.

Dudley J. Kimball was unanimously elected vice-president of the N.A.S.E. at the recent convention at Buffalo, N. Y. It is the custom of the society for the vice-president to be elected president in the succeeding year, in consequence of which the election of a vice-president is always hotly contested. This year, however, for the second time in the history of the organization the choice of Mr. Kimball as vice-president was unanimous.

Last year, Mr. Kimball, who has been an earnest and enthusiastic worker in the N. A. S. E. for years and particularly well known in the Eastern circuit, was a candidate for the vice-presidency and when defeated he took his defeat in such a sportsmanlike and pleasant way that when his name came up this year, he scored by being given a unanimous election to the vice-presidency.

One coffee firm of Boston has used for more than a century and is still using a mill operated by tide power.

Collins Completes Utica Coal Survey

Hubert E. Collins, consulting engineer, of Utica, has recently completed a coal survey for Utica and Herkimer Counties, N. Y. He made the survey at the request of the A. F. E. S. and was assisted generously by the citizens of the two counties.

The total requirements of the two counties for a given year were found to be 1,641,165 tons; 1,025,761 tons bituminous and 615,404 tons anthracite. The bituminous coal, it was found, was almost entirely consumed by industrial plants, 33⅓ per cent being for heat, 33⅓ per cent power and 33⅓ per cent for process. Anthracite was principally used for domestic, school and hospital heating, although 18,000 tons was used in the production of gas. Of the total amount of coal used, 360,000 tons was handled through dealers. Need of education in the storage of coal was noted.

There was found a lack of measuring instruments in boiler rooms and a consequent lack of power-plant records. Only four plants were found, in the whole district, where coal and feedwater records were measured each day.

Standardization of Marine Work and Practice to Begin

Preliminary steps have been taken by the American Marine Standards Committee to form subject committees to study and develop standards for certain hull and engineering details and certain phases of operation practice. These subject committees are formed by the technical committees appointed as per previous announcement, and their work is to be carried on independently, but the results thereof are subject to review by their respective technical committees, and report is made to the Executive Board to have the results passed upon and the appropriate status given thereto either as "Suggested American Marine Practice" or "Tentative American Marine Standard" or "American Marine Standard," as provided by the Constitution and Rules of the Organization. Before, however, such action is taken all concerned in the marine field are to be given opportunity to criticize or approve the results or to make recommendations for their betterment.

Subject committees are now in process of formation covering the following subjects:

On condenser tube specifications. (This committee is to review the work already accomplished by the American Society for Testing Materials with a view to adoption of the specifications issued by that body as the marine standard); on condenser tube ferrules. (This committee is to develop standards of design; specifications for the material are to be considered by Committee No. 3); on care and operation of boilers; on care and operation of main engines exclusive of condensers; on care and operation of engine-room auxiliaries including piping, condensers and cargo

pumping plants; on care and operation of oil-burning apparatus and handling of fuel oil; on lubrication.

Navy Dept. Needs Mechanical Engineer

The United States Civil Service Commission announces an open non-assembled competitive examination for assistant mechanical engineer (internal-combustion engines). The examination is to fill a vacancy in the Bureau of Aëronautics, Navy Department, at an entrance salary of $6.40 a day, and vacancies in positions at salaries ranging from $2,000 to $2,400 a year. Requirements are, graduation from an engineering, preferably mechanical, college of recognized standing, and to have had at least two years' experience, or post graduate work in mechanical engineering as it applies to the design, construction or testing of internal-combustion engines for automobiles or aircraft. The duties of the position are to act as technical adviser to the officer-in-charge. Receipt of application will close November 6.

New Publications

Protesting Drafts in South, West and East Africa, with a Brief Discussion of the South African Laws and Customs Relating to Insolvencies, Merchandise and Insurance. Compiled by A. J. Wolfe. Trade Information Bulletin No. 36, Supplement to Commerce Reports, United States Dept. of Commerce, Washington, D. C. Free.

Comparative Tests of Byproduct Coke and Other Fuels for House Heating—Technical Paper No. 315. By Henry Kreisinger, John Blizzard, H. W. Jarrett & J. J. McKitterick. Published by the Bureau of Mines. Government Printing Office, Washington, D. C. Paper; 6x9 in.; 21 pages. Price, 5 cents.

The Federal Fuel Distributor has sent this pamphlet out in the hope that householders may become better acquainted with coke as a substitute for anthracite for the heating of houses. The pamphlet contains the results of 44 tests made in the fuel laboratories of the Pittsburgh Experiment Station and the Minneapolis Station of the Bureau of Mines with small steam boilers of similar size to those used in heating small apartment houses and seven- and eight-room houses. The tests showed that byproduct coke, besides being very cleanly, gave as high efficiency as bituminous or anthracite if not higher, and that a much more uniform temperature was obtained, with the same attention to the fire as given when bituminous coal was used, than with bituminous coal. The pamphlet also gives some condensed rules for the burning of coke in house-heating equipment from Technical Paper No. 242 as follows: Carry a deep bed of fuel, one about 18 inches thick gives the best results; use very little draft after the fire is started, and keep it always under control; the success of even heating depends on careful draft regulations; do not stir the fuel bed; clean the fire in the morning; use sized coke, ½ to 2 in. for furnaces, boilers and stoves, ½ to 4 in. for open grates; do not allow ash to accumulate in the ashpit.

Tabelien und Diagramme für Wasserdampf Berechnet aus der Spezifischen Wärme (Tables and diagrams for steam computed on the basis of the specific heat). By Dr. E. H. Oscar Knoblauch, E. Raisch and H. Hausen. Published by R. Oldenbourg, Glückstrasse 8, Munich, Germany. Paper; 7½x10½ in.; 32 pages, 4 tables and 3 large diagrams (folded inserts). Price, 50 cents.

The authors, and particularly Dr. Knoblauch, are well known for previous work on the steam tables. This book is based on the results of 20 years' research, in the Munich Laboratory of Technical Physics, to determine as precisely as possible the relation between the specific heat of superheated steam and the temperature for various pressures. Constant-pressure curves were plotted from these experiments, and an equation derived connecting the three variables (specific heat, temperature and pressure). This equation was so formed as to agree not only with the experimentally determined values, but also to give the known proper values at zero pressure and the critical pressure. From this equation the complete set of constant-pressure curves up to 60 atmospheres was plotted. With this relation as a basis the authors worked out, on a purely thermodynamic basis, equations for specific volume, entropy and heat content. The derivation of these equations as given in the book will be of great interest to those engaged in steam-table research. The average American engineer will doubtless find the combination of mathematics and the German language too much for the time he can afford for this part of the book. Any engineer, however, who is familiar with the use of ordinary steam tables and diagrams needs but a slight acquaintance with German to make use of the tables and charts. Of the four tables given, the first and the fourth are merely steps in the preparation of the other two and may be passed over without comment. Tables 2 and 3 are saturated-steam tables in the familiar form (except of course that all figures are in metric units), one being entered with the pressure and the other with the temperature. These tables extend to 60 atmospheres (about 900 lb. per sq.in.). The diagrams are as follows: (1) Constant-pressure curves, 0 to 60 atmospheres, showing specific heats for temperatures from 200 deg. C. to 500 deg. C.; (2) total-heat entropy diagram extending to 60 atmospheres and 450 deg C.; (3) total-heat pressure diagram (logarithmic total-heat scale) with curves of constant quality, constant temperature and constant specific volume, limits 60 atmospheres and 450 deg. C. A somewhat longer review giving the final equations and the specific-heat curves may be found on page 538 of the August issue of *Mechanical Engineering.*

Physics In Industry. Lectures delivered before the (British) Institute of Physics by Archibald Barr, Sir James Alfred Ewing and Clifford Paterson. Published by Oxford University Press, American Branch, New York City, 1923. Boards; 6x9½ in.; 59 pages. Price, 85 cents.

If there had been no science of physics, pure physics, modern engineering would never have been born. The steam engine, the turbine, the electric motor and generator all owe their start and much of their growth to men who devoted their lives to a study of physics. At the same time engineering has made some return to physics in the form of new data, new inspiration and new financial support. The engineer who enjoys, now and then, a little scientific reading somewhat outside the immediate necessities of his daily work, will find much of interest in this little book. The first lecture, by Professor Barr, shows how engineering combines pure physics with rule of thumb and intuition. In the second, Sir James Ewing paints an interesting picture of the contributions to steam engineering of such men as Kelvin, Watt, Parsons, Carnot, Regnault, Joule and others. The third lecture, by Clifford Paterson, is a practical discussion by a man on the inside, of the relation of research laboratories to industry and, in particular, to the electrical industry.

Society Affairs

The Providence Section of the A.S.M.E. in connection with the Providence Engineering Society will have a meeting on Nov. 20, at which the question of coal storage will be discussed.

The Metropolitan Section of the A.S.M.E. in the early part of next year intends to hold a meeting, probably in Newark, N. J., at which the coal-storage problem in this territory will be discussed.

The St. Louis Section of the A.S.M.E. will hold a dinner meeting at the American Annex Hotel, Sept. 27, at 6 p.m. A talk "Engineering Features in Development of Airplanes," by B. Russell Shaw, and music will add to the enjoyment of the evening.

The Chicago Section of the A.S.M.E. on Sept. 20 held an opening booster meeting at the University Club. A questionnaire, to determine the choice of topics for discussion, called forth a wide diversity of opinion. Industrial processes headed the list as the most desirable topic, with about one-fourth of the replies favoring subjects on power development. The campaign on smoke prevention and coal storage were also favorably received as offering opportunities for service. A buffet supper, music and a comic movie added to

the joy of the occasion and brought into intimate contact the two hundred members in attendance.

The West Virginia-Kentucky Association of Mine, Mechanical and Electrical Engineers are planning to hold their third annual convention at the Frederick Hotel Huntington, W. Va., Oct. 19-20. The program which will be of interest to readers of *Power* is as follows: Mechanical and Electrical Equipment Records," by J. H. Edwards; "Purchased Power vs. Individual Plants," an open discussion; "Construction and Care of Transformers," (illustrated by slides) by L. G. Mason of the Westinghouse Electric & Mfg. Co.; "What Can Be Done To Improve the Efficiency of Mine Pumping," by C. E. Rogers, J. L. Butcher, A. E. Harris; "What Service Are We Getting from the Manufacturers in Supplying Supply Parts," by F. M. Reigher; "Hoisting Equipment," by M. A. Maxwell; "Application of Fan Drive for Ventilation," by J. J. Fluck.

Trade Catalogs

Couplings, Flexible — Charles Bond Co., 617 Arch St., Phila., Pa. Booklet F gives description, sizes and photos of Grundy flexible insulated, and Mather flexible couplings.

Motors, Polyphase Induction—Allis-Chalmers Manufacturing Co., Milwaukee, Wis. Bulletin 1118-B gives descriptions and illustrations of type AR squirrel-cage polyphase induction motors.

Hoists, Telescopic—Gillis & Geoghegan, 558 West Broadway, New York City. Catalog illustrating and describing electric and hand power hoists for use in handling ash cans, barrels, bales and other loads.

Flue-Gas Sampling Line—Uehling Instrument Co., 473 Getty Ave., Paterson, N. J. Bulletin No. 116-A describes with text and pictures "pyro-porus," gas drier, gas purifier and gas line tubing which are accessories for CO_2 recorders.

Compressors — Sullivan Machinery Co., Chicago, Ill. Bulletin No. 77-G (replacing 77-C) describes with numerous illustrations and tables of details the Sullivan "WA-6" single-stage, steam-driven, straight-line air compressors.

Stoker, Chainless — CoKal Stoker Corp., 341 East Ohio St., Chicago, Ill. Catalog which describes a manually operated mechanical stoker is well illustrated and gives full descriptions of processes of feeding and combustion as well as construction.

Pulverized Fuel Systems, Lopulco—Combustion Engineering Corp., Broad St., New York City. Catalog L-1 shows the installation and working of this pulverized-fuel system. Tables of installations in operation, with size and ratings, and of evaporative tests of Lopulco-equipped boilers as well as numerous explanatory drawings and photos, make this a useful as well as attractive catalog.

Valves—J. H. H. Voss, 154 Nassau St., New York City. *Voss Valve News* contains an article on "Ammonia Compressor Valve Design," which is well illustrated and interestingly written.

Coming Conventions

The American Association for the Advancement of Science. Burton E. Livingston, Smithsonion Institution Bldg., Washington, D. C. Seventy-fifth anniversary meeting at University of Cincinnati, Cincinnati, Ohio, Dec. 27-Jan. 2.

American Electric Railway Engineering Association. James W. Welsh, 8 West 40th St., New York City. Annual Convention at Young's Pier, Atlantic City, Oct. 8-12.

American Institute of Electrical Engineers, F. L. Hutchinson, 29 West 39th St., New York City. Pacific Coast Convention at Del Monte, Calif., Oct. 2-5.

The American Society of Civil Engineers. John H. Dunlap, 29 West 39th St., New York City. Fall meetings, Richmond, Va., Oct. 17-20.

American Society of Mechanical Engineers, Calvin W. Rice, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 3-6. Regional meeting at Chattanooga, Tenn., Oct., 23-24.

American Society of Refrigerating Engineers, William H. Ross, 35 Warren St., New York City. Nineteenth Annual Convention at New York City, Dec. 3-5.

American Welding Society. M. M. Kelly, 33 West 39th St., New York City. Fall Meeting, Pittsburgh, Pa., Oct. 24-26.

Association of Railway Electrical Engineers. Jos. A. Andreucetti, Room 413, Chicago & Northwestern R.R. Station, Chicago, Ill. Thirteenth Annual Convention at Hotel La Salle, Chicago, Ill., Nov. 6-9.

Electric Power Club, S. N. Clarkson, 900 B. F. Keith Bldg., Cleveland. Fall meeting at French Lick Springs Hotel, French Lick, Ind. Nov. 19-22.

Empire State Gas & Electric Association. Charles H. B. Chapin, Grand Central Terminal Bldg., New York City. Meeting at Lake Placid, N. Y., Oct. 8-9.

National Association of Practical Refrigerating Engineers; Ed. H. Fox, 5707 W. Lake St., Chicago. Fourteenth Annual Convention at Memphis, Dec. 12-16.

National Exposition of Power and Mechanical Engineering; Charles F. Roth, Room 1102, Grand Central Palace, New York City. Power Show, Dec. 3-8.

National Safety Council, W. H. Cameron, 168 North Michigan Ave., Chicago, Ill. Twelfth annual congress at the New Statler Hotel, Buffalo, N. Y., Oct. 1-5.

New England Association of Commercial Engineers; James F. Morgan, 53 Devonshire St., Boston, Mass. Power Show at Mechanics Bldg., Boston, Mass., Oct. 29-Nov. 3.

Society of Naval Architects and Marine Engineers, Daniel H. Cox, 29 West 39th St., New York City. Anual meeting at New York City, Nov. 8-9.

West Virginia-Kentucky Association of Mine, Mechanical and Electrical Engineers; Herbert Smith, Room 211, Robson-Prichard Bldg., Huntington, W. Va. Third annual convention at Frederick Hotel, Huntington, W. Va., Oct. 19-20.

Packing Condenser, Metallic—Crane Packing Co., Chicago, Ill. Revised 30-page booklet on condenser-tube disintegration and testing, types of packing used and the crane process.

Aftercoolers, Counter-Current—Nordberg Manufacturing Co., Milwaukee, Wis. Leaflet of 8 pages devoted to the advantages of dry air and the essentials of a properly designed aftercooler with outlines of the tubular and spray types made by the company.

Valve, Controller—The Bristol Company, Waterbury, Conn. Bulletin No. 319 describes the Bristol-Fuller controller valve for air, gas, water and steam, the Bristol temperature controller models No. 376 and 473 and the recording pyrometer model 437.

Refractories and Furnace Design—Jointless Fire Brick Co., 1130 Clay St., Chicago, Ill. This catalog takes up the design and building of furnaces and discusses the merits of and the way of installing "Plibrico" a jointless furnace lining. It presents in a satisfactory manner the method of installation and the vitrifying as well as the repairing and conditioning of this refractory. Various settings, such as smoke prevention, chain grate, a typical installation, water tube, horizontal return tube, are given, with many drawings and tables of dimensions.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Sept. 17, 1923	Sept. 24, 1923
Pool 1,	New York	$3.00@3.50	$3.00@3.50
Smokeless,	Columbus	2.75@3.25	2.75@3.25
Clearfield,	Boston	1.80@2.50	1.85@2.50
Somerset,	Boston	2.00@2.75	2.00@2.75
Kanawha,	Columbus	1.75@2.10	1.75@2.10
Hocking,	Columbus	1.85@2.00	1.85@2.10
Pittsburgh No. 8	Cleveland	2.00@2.10	2.00@2.10
Franklin, Ill.	Chicago	2.75@3.25	2.75@3.25
Central, Ill.	Chicago	2.10@2.35	2.10@2.35
Ind. 4th Vein,	Chicago	2.50@2.75	2.50@2.75
West Ky.,	Louisville	1.85@2.10	1.75@2.10
S. E. Ky.,	Louisville	1.75@2.25	1.75@2.25
Big Seam,	Birmingham	1.75@2.15	1.75@2.15

FUEL OIL

New York—Sept. 27, light oil, tank car lots, 28@34 deg. Baumé, 3¾c. per gal., 36@40 deg. 4c. per gal., f.o.b. Bayonne, N. J.

Chicago — Sept. 17, 24@26 deg. Baumé, $1.82@2.07 per bbl.; 32@36 deg., $2.02@2.07 per bbl., tanks cars.

St. Louis—Sept. 18, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.70@1.75 per bbl.; 26@28 deg., $1.90@1.95; 28@30 deg., $2@2.05; 32@36 deg., gas oil, 4¾c. per gal.; 36@40 deg., distillate, 5¼@5½c. per gal.

Pittsburgh—Sept. 21, f.o.b. local refinery, 30@34 deg., fuel oil, 4¾c. per gal.; 36@40 deg., fuel oil, 5¼c.; 34 deg., neutral 7c.

Dallas—Sept. 21, f.o.b. local refinery, 26@30 deg., $1.35 per bbl.

Cincinnati—Sept. 18, tank-car lots f.o.b. local refinery, 26@30 deg. Baumé, 4¼c. per gal.; 30@32 deg., 4½c.; 38@42 deg., distillate, 5¾c.

Philadelphia—Sept. 22, 26@28 deg., $1.68@1.722 per bbl.; 16@20 deg., $1.64@1.68; 14@16 deg., $1.57@1.612.

New Plant Construction

PROPOSED WORK

Ark., Hot Springs—Mann & Stern, Archts., A.O.U.W. Bldg., Little Rock, will receive bids until Oct. 6 on revised plans for the construction of an 11 story, 200 x 200 ft. hotel for the Arlington Hotel Co., Central Ave., here. Estimated cost $2,225,000. Noted May 22.

Calif., Los Angeles—A. C. Blumenthal, et al., Loew State Bldg., is having plans prepared for the construction of a 12 story, 115 x 200 ft. apartment house on Hollywood Blvd. K. Macdonald, Brack-Shops Bldg., Los Angeles, Archt. Equipment detail not reported. Noted July 3.

Calif., Los Angeles—A. C. Blumenthal, et al., Loew State Bldg., is having plans prepared for the construction of a 14 story salesroom and office building on Broadway near 9th St. Cost will exceed $500,000. K. Macdonald, Brack-Shops Bldg., Los Angeles, Archt. A portion of the building will be leased to the R. Wurlitzer Co., 605 West 7th St. Equipment detail not reported. Noted Aug. 7.

Calif., Los Angeles—Cahn-McCabe & Co., 716 South Spring St., is having plans prepared for the construction of a 13 story, 60 x 150 ft. store, loft and office building on 7th and Spring Sts. Norton & Wallis, Pacific Finance Bldg., Archts. Equipment detail not reported. Noted Aug. 28.

Calif., Los Angeles—The city received bids for the general contract for the construction of a 2 story auditorium and boiler house for Hollywood High School from the Kinne-Westerhouse Co., H. W. Hellman Bldg., $294,000; North Pacific Constr. Co., Detwiler Bldg., $299,850; B. D. Kronnick, 3623 South Park Ave., $304,000. Noted Sept. 4.

Calif., Los Angeles—J. B. Fahy, et al., c/o O. H. Neher, Archt., Marsh-Strong Bldg., are having plans prepared for the construction of a 13 story, 100 x 150 ft. office building on South Spring St. H. Hasenberger, Marsh-Strong Bldg., Engr. Equipment detail not reported.

Calif., Los Angeles—J. Foote is having plans prepared for the construction of a 12 story, 60 x 128 ft. hotel on Bixel and Ingraham Sts. Estimated cost $600,000. L. L. Jones, 603 Grosse Bldg., Los Angeles, Archt. Equipment detail not reported.

Calif., Los Angeles—A group of local capitalists is having plans prepared for the construction of a 13 story, 100 x 155 ft. office building at 823 South Spring St. Estimated cost $1,050,000. Neher & Hasenberger, 209 Marsh-Strong Bldg., Los Angeles, Archts. Equipment detail not reported.

Calif., Los Angeles—Morgan, Walls & Morgan, Archts., Van Nuys Bldg., are receiving bids for the construction of a 2 story, 100 x 200 ft. milk plant, 1 story, 80 x 80 ft. boiler house and a 2 story, 93 x 200 ft. ice cream plant on Slausson Ave. for the Crescent Creamery Co., 237 Winston Ave. Noted July 24.

Calif., Los Angeles—Robbins & Co., 3115 Maple St., are having plans prepared for the construction of a 12 story, 42 x 165 ft. store and loft building on South Broadway. Estimated cost $600,000. Norton & Wallis, 716 South Spring St., Los Angeles, Archts. Equipment detail not reported.

Calif., Oroville—E. J. Robinson, Route B, plans to install one 10 in. centrifugal pump operated by 33 hp. electric motor, also pipe.

Calif., Oroville—G. Wilkinson has been granted a permit by the state to appropriate water and plans to build a dam, 35 ft. high, 275 ft. on top, 50 ft. on bottom; 20 x 20 ft. tunnel, 800 ft. long; conduit 6,000 ft. long, 500 ft. wide, 15 ft. deep, consisting of an existing concrete wall in river bed, which will be enlarged; power house developing 47,659 hp. by impulse wheels and turbines at a fall of 2,418 ft. Estimated cost $300,000.

Calif., San Francisco—The Baker-Hamilton & Pacific Co., 700 7th St., plans to build a 6 story, 137 x 550 ft. warehouse, loft and office building on Beale St. between Bryant and Brannan Sts. Estimated cost $1,000,000. Engineer or architect not selected.

Calif., San Pedro—D. Barnes, c/o O. H. Neher, Archt., Marsh Strong Bldg., Los Angeles, is having plans prepared for the construction of a 15 story hotel on 7th St. and Pacific Blvd., here. Equipment detail not reported.

Calif., San Pedro—L. de Carlo, c/o L. L. Jones, Archt., Crosse Bldg., Los Angeles, is having plans prepared for the construction of a 6 story hotel on 7th St., here. Estimated cost $250,000. Equipment detail not reported.

Colo., Denver—J. Fowler, 2555 West 37th St., is in the market for a 60 to 75 hp. oil engine.

Conn., Hartford—The School Bd., Municipal Bldg., will readvertise for bids for the construction of a 3 story high school on Maple Ave. Estimated cost $1,200,000. E. T. Wiley, 75 Pratt St., Archt. Former bids rejected. Noted Sept. 4.

Conn., Rockyhill—The Belamose Corp., 303 5th Ave., New York, is having plans prepared for the construction of a 1 story, 140 x 600 ft. factory for the manufacture of silk, two 2 story storehouses and a 1 story, 50 x 70 ft. boiler house, here. Private plans.

Florida—The Florida Auto-Tel System, Orlando, M. O. Overstreet, Pres., is having plans prepared for the construction of a chain of fifteen hotels, one at Orlando and one at Vero to be built at once, estimated cost $100,000 each. Total cost $1,000,000. Private plans. Equipment detail not reported.

Fla., Tampa—I. T. Roberts, Birmingham, Ala., is having plans prepared for the construction of a hotel, here. Estimated cost $2,000,000. M. L. Elliott, Citizens Bank Bldg., Tampa, Archt. Equipment detail not reported.

Ill., Chicago—Huszaah & Hill, Archts., 105 North Clark St., are receiving bids for the construction of a 3 story apartment house, including steam heating system, on Rogers Ave. and East Lake Terrace for A. Ingram, c/o Archt. Estimated cost $500,000. Noted Aug. 21.

Ill., Chicago—M. P. Morrissey, c/o R. F. France, Archt., 155 North Clark St., is having plans prepared for the construction of three 3 story, 250 x 300 ft. apartment buildings, including steam heating system, on Oak Park and Erie Sts. Estimated cost $800,000.

Ill., Mason—The Illinois Coal Corp., Old Colony Bldg., Chicago, awarded the contract for 1 story, 40 x 140 ft. warehouse, 50 x 140 ft. shop, 60 x 60 ft. power plant and a hoist and engine house to the H. N. Leighton Co., 127 South 10th St., Minneapolis, Minn. Estimated cost $150,000.

Ill., Metropolis—The city is having plans prepared for the construction of waterworks plant, equipment and distribution mains; also for reconstruction of electric light plant and transmission system. Estimated cost $100,000, $55,000 bonds recently voted, remainder to be financed by special tax. W. A. Fuller Co., 1917 Railway Exch. Bldg., St. Louis, Mo., Engrs.

Ind., Jasonville—The City Council is receiving bids for electrically operated pumping machinery for new waterworks. Estimated cost $100,000. A. Simms, Engr.

Ia., Albia—The city voted $80,000 bonds and will soon award contracts for the construction of an impounding dam, storage reservoir, pumping station and filtration plant. Burns & Cook, Ottumwa, Engrs.

Ia., Sioux City—The Mother Superior of St. Joseph's Mercy Hospital is having plans prepared for the construction of a 5 story addition to hospital on 21st and Court Sts. Estimated cost $275,000. J. Wheeler, Exch. Bank Bldg., St. Paul, Minn., Archt. Equipment detail not reported.

Kan., Dresden—The city voted $22,500 bonds for the construction of an electric light plant, distribution system and transmission line from here to Oberlin. Electric Development Co., Omaha, Neb., Engrs. Noted Sept. 4.

Ky., Lexington—The University of Kentucky plans to build a central heating plant for all the university buildings. Estimated cost $250,000. Engineer or architect not selected.

La., Monroe—The Acme Carbon Mfg. Corp., 844 Ouachita Natl. Bank Bldg., plans to build a plant, first unit to consist of thirty 12 x 120 ft. burning houses, 25 x 75 ft. warehouse, 30 x 50 ft. packing house, 20 x 30 ft. machine shop, 12 x 25 ft. office, etc.

La., Pecan Island—E. A. McLhenny, 355 Drexel Bldg., Phila., Pa., Pres., representing owners, plans to build a winter resort and club house, here. Estimated cost $2,000,000.

Md., Baltimore—The Standard Electric Mchy. Co., 7-9 East Hill St., is in the market for one 225 hp. and one 450 hp. slip ring, 3 phase, 25 cycle, 220, 440, 550 or 2,200 volt motors and controls.

Mich., Detroit—The Apartments Co., c/o Brown & Derrick, Archts., Capitol Theatre Bldg., is having plans prepared for the construction of a 10 story, 50 x 150 ft. apartment, including steam heating system, on Jefferson and Hibbard Aves.

Mich., Marquette—The city, c/o Clerk, City Hall, is having plans prepared for the construction of a dam and penstock on the Dead River near here. Estimated cost $50,000. Orbison & Orbison, 812 College Ave., Appleton, Wis., Engrs. Noted Sept. 25.

Mo., Greenfield—The city voted $60,000 bonds for the construction of a pumping plant, reservoir and distribution mains. Engineer or architect not announced.

Mo., Ironton—The city is having preliminary plans prepared and plans an election to vote $40,000 bonds for the construction of a pumping plant, reservoir, distribution mains, etc. J. D. Davis, Jefferson City, Engr.

Mo., Ridgeway—The city voted $45,000 bonds for the construction of a pumping plant, reservoir, distribution mains, etc. Shockley Eng. Co., 800 Graphic Arts Bldg., Kansas City, Engrs. Noted Sept. 4.

Mo., Thayer—The city holds an election Oct. 2 to vote $55,000 bonds for the construction of a pumping plant, reservoir, distribution mains, etc. R. B. Alexander, Kansas City, Engr.

N. J., Waldwick—The Mayor and Borough Council, W. R. Evans, Clk., will receive bids Oct. 4 for furnishing two vertical shaft water turbines, two vertical triplex plunger pumps and one 250 g.p.m. centrifugal pump. J. L. Collins, 30 Church St., New York, Consult. Engr.

N. Y., Buffalo—The Mercy Hospital, Abbott Rd. and Choate Ave., is having preliminary plans prepared for the construction of a 3 story, 200 x 350 ft. hospital on Abbott Rd. Estimated cost $400,000. Engineer or architect not announced.

N. Y., New York—The Bd. Educ., 500 Park Ave., received bids for the construction of James Monroe High School on Boynton Ave. and 172nd St. from the Willetts Constr. Co., 280 Madison Ave., (A) $2,057,000, (B) $2,170,000, (C) $2,370,000; T. Dwyer, Broadway and 216th St., (A) $2,200,000, (B) $2,280,000, (C) $2,600,000; T. A. Clarke Co., (A) $2,237,000, (B) $2,317,000. Noted Sept. 18.

N. Y., North Tonawanda—The North Tonawanda Power Co. plans to build a supply station and transformer on River Rd. and Sommer St. Estimated cost $50,000. Engineer or architect not announced.

N. Y., Rochester—The Baptist Church Bldg. Com., c/o C. Wunder, 12 Franklin St., is having plans prepared for the construction of a 9 story church and office building. Estimated cost $2,000,000. C. Trayer, Rochester, Engr. Gordon & Kaelber, Sibley Bldg., Rochester, Archts. Equipment detail not reported.

N. Y., Rochester—The University of Rochester, 1490 University Ave., G. W. Todd, 1050 University Ave., Chn. Citizens' Com., plans to build several buildings. Estimated cost $10,000,000. Engineer or architect not announced.

N. C., Burlington—The Queen Anne Textile Co., W. H. Morton, Adams, Mass., Pres., plans to build and equip a cotton mill, here. Estimated cost $1,000,000.

N. C., Parkton—The town, W. W. Gainey, Clk., will receive bids until Oct. 9 for furnishing and installing fourteen distribution transformers, one regulating transformer, one time switch, forty-nine street lighting units, etc. T. D. Rose, Fayetteville, Consult. Engr.

N. C., Waynesville—The Pigeon River Power Co. has applied to the Federal Power Comn. for authority to develop water power on the Pigeon River, including construction of a dam, 150 ft. high and a 5 mi. tunnel to power house at Waterville, initial installation 50,000 hp., ultimate development 150,000 hp. Noted June 19.

Ohio, Cleveland—The City Ice & Fuel Co., Cadillac Bldg., H. D. Norrvell, Pres., is having plans prepared for the construction of a 1 story, 79 x 158 ft. ice plant on East 124th St. and Union Ave. Estimated cost $60,000. A. C. Bishop & Co., Guardian Bldg., Cleveland, Archts.

Ohio, Cleveland—The Cleveland Union Terminals Co., c/o O. P. and M. J. Van Swerigen, Marshall Bldg., is having plans prepared for the construction of a 10 and 14 story passenger station and freight terminal building, including tracks and

bridges, on Public Sq. Estimated cost $60,000,000. H. D. Jouett, Ch. Engr. Graham Anderson Probst & White, 80 East Jackson Blvd., Chicago, Archts. Equipment detail not reported.

Ohio, Cleveland—Knox & Elliot, Archcts., 906 Engineers Bldg., will receive bids until Oct. 15 for the construction of a 20 story, 132 x 168 ft. bank and officec building on Ontario St. and St. Clair Ave. for the Brotherhood of Locomotive Engineers, Engineers Bldg., W. S. Stone, Pres. Estimated cost $5,000,000. Equipment detail not reported. Noted June 5.

Ohio, Mansfield—The Natl. Ice Co. is receiving bids for the construction of a 1 story, 41 x 60 ft. ice plant. Estimated cost $40,000. A. C. Bishop & Co., 830 Guardian Bldg., Cleveland, Archts.

Ohio, Navarre — The County of Stark, Canton, is having plans prepared for the construction of a 2 story tuberculosis hospital, 100 bed capacity, near here. Cost between $250,000 and $300,000. Thayer & Johnson, Newcastle, Pa., Archts. Equipment detail not reported.

Okla., Holdenville — The city voted $67,250 bonds for the construction of a settling basin, filters, high and low service pumps and equipment. C. E. Edge, Holdenville, Engr. Noted Aug. 14.

Okla., Okmulgee—The Creek Hotel Co., W. B. Pine, Pres., is having plans prepared for the construction of a 7 story, 125 x 200 ft. hotel, including low pressure steam heating system on Cherokee St. Estimated cost $600,000. Smith & Senter, Okmulgee, Archts.

Okla., Tulsa—The City Water Comn., A. J. Rudd, Chn., will receive bids until Oct. 26, for the construction of a portion of the Spavinaw water supply project, including (14) Mohawk pumping station, pump foundations, aerator, receiving well, intake well, piping, valves, sluice gates, equipment and appurtenances; (15) 150 ft. chimney; (16) c.i. or steel force main. J. D. Trammell and W. R. Holway, 508 Wright Bldg., Tulsa, Engrs. D. H. Maury, 1445 Monadnock Block, Chicago, Consult. Engr. Noted Aug. 21.

Pa., Phila.—The Bell Telephone, 17th and Arch Sts., will receive bids until Oct. 3 for the construction of a 2 and 3 story, 91 x 220 ft. central building at 3808-10 Chestnut St. Estimated cost $700,000. J. T. Windrim, Commonwealth Bldg., Phila., Archt.

Pa., Wilson — The Carnegie Steel Co., Carnegie Bldg., Pittsburgh, plans to install a conveyor system for loading coal on river barges, here. Estimated cost $35,000.

S. D., Watertown—The city rejected bids for waterworks improvements, including filter, pump and pipe equipment for filter house and pumping station. Noted Aug. 21.

Tenn., Knoxville—The University of Tennessee is in the market for two turbine generators, 300 kw. each.

Tenn., Lawrenceburg—The Mayor is receiving bids for the construction of a dam and power station at Shoals Creek. Freeland & Roberts, Independent Life Bldg., Nashville, Engrs. Noted Sept. 11.

Tex., Fort Worth—The city will hold an election in December to vote from $1,000,000 to $1,500,000 bonds for the construction of a municipal building on Throckmorton St. Engineer or architect not announced. Noted Sept. 18.

Tex., Fort Worth—The city and Tarrant County plan to build a hospital on South Main St. Estimated cost $1,000,000. The city plans an election to vote $500,000 bonds and the county plans to issue warrants for $500,000. Engineer or architect not selected.

Va., Norfolk — The Taylor-Parker Co., Water St. and Commerce Pl., C. A. McLean, Purch. Agt., is in the market for a 100 hp. engine and three 100 hp. return tubular boilers complete with stacks, etc., about 125 lb. pressure, half fronts, preferred.

Wash., Seattle—The Metropolitan Bldg. Co., Henry Bldg., is having plans prepared for the construction of a 6 story Medical Building with special equipment for doctors' and dentists' offices on 4th and Seneca Sts. Estimated cost $1,250,000. Howells & Albertson, Henry Bldg., Archts.

Wash., Tacoma—The city plans an election Oct. 18 to vote $2,400,000 school bonds, once adopted and later invalidated by a Supreme Court decision.

Wis., Cedar Grove — Dick & Bauer, Archts., 811 State St., Milwaukee, are receiving bids and will open same about Oct. 4 for the construction of a 2 story, 32 x 100 ft. factory for the Cedar Grove Shoe Mfg. Co., here. Estimated cost $42,000. The owner is in the market for shoe working machinery equipped with individual motors.

Wis., Lone Rock—The Wisconsin Power, Light & Heat Co., Gay Bldg., Madison, plans to build a power dam across the Wisconsin River, here. Estimated cost $25,000. Engineer not selected.

Wis., Madison—The Madison Medical Assn., c/o R. S. Ingersoll, Lakeside St., plans to build a boiler house, laundry and garage. Estimated cost $50,000. Engineer or architect not selected. The owner is in the market for boilers, etc.

Wis., Milwaukee — Holabird & Roche, Archts., 104 South Michigan Ave., Chicago, are preparing revised plans and will soon receive new bids for the construction of a 12 and 15 story, 50 x 70 x 150 ft. addition to hotel for the Hotel Wisconsin Realty Co., 172-80 3rd St., here. Estimated cost $1,300,00. Equipment detail not reported. Noted July 10.

Wis., Waukesha—M. Tullgren & Sons Co., Archts., 425 East Water St., Milwaukee, will soon award the contract for the construction of a 3 story hotel on Hartwell Ave. for the Hotel Silurian, c/o F. J. Strong, 151 South East Ave., here. Estimated cost $350,000. Equipment detail not reported.

Wis., Woodman—The village, W. K. Lull, Clk., plans to build an electric light system, including a power station and a 10 mi. transmission line from Wauzeka. Engineer or architect not selected.

Ont., Toronto—The Hydro-Electric Power Comn., 190 University Ave., A. Beck, Chn., will receive bids until Oct. 15, for the excavation of a tailrace channel.

Que., Quebec — The Harbor Comrs., C. Smith, Sec., will receive bids until Oct. 10 for the construction of a cold storage warehouse, power plant and fish storage plant. Bids will be considered for the whole plant complete or for the following items, separately: machinery, including piping, power wiring, etc., for power plant; piping including all cooling coils and connections from and to the brine coolers, heating apparatus and air conditioning machines, airducts, etc.; electric wiring; insulation; elevators; sprinklers; buildings.

CONTRACTS AWARDED

Calif., Los Angeles—The M. G. Cooper Co., 700 South Los Angeles St., awarded the contract for the construction of a 2 and 11 story store and loft building on 9th and Los Angeles Sts., to the McNeil Co., H. W. Heilman Bldg., Los Angeles. Estimated cost $600,000. Heating system, etc., will be installed under separate contracts.

Calif., Los Angeles—The Natl. City Bank awarded the contract for the construction of a 13 story, 102 x 120 ft. bank and office building on 8th St. between Main and Spring Sts., to the Edwards, Wildey & Dixon Co., Black Bldg., Los Angeles. Estimated cost $795,000. Equipment detail not reported.

Calif., Los Angeles—The Sun Realty Co. awarded the contract for the construction of a 12 story, 86 x 160 ft. office building on 9th and Olive Sts. to Macdonald & Kahn, Loew State Bldg., Los Angeles. Estimated cost $850,000. Equipment detail not reported.

Calif., Pasadena—The Pacific Southwest Trust & Savings Bank, 565 South Spring St., Los Angeles, awarded the contract for the construction of an 8 story bank and office building on Marengo and Colorado Sts., here, to the Scofield Eng. Co., Pacific Finance Bldg., Los Angeles. Cost will exceed $1,000,000. Equipment detail not reported. Noted Sept. 11.

Calif., San Diego—The Sisters of Mercy, 700 University Ave., awarded the contract for the construction of a 6 story, 42 x 250 ft. hospital, also a 1 story, 60 x 65 ft. kitchen building on Hilcrest Dr. to the W. E. Kerr Constr. Co., San Diego. Estimated cost $650,000. Equipment detail not reported.

Calif., Santa Monica—The Miramar Hotel Co. awarded the contract for the construction of a 4 story, 80 x 286 ft. hotel to Gutleben Bros., 609 I. W. Hellman Bldg., Los Angeles. Estimated cost $325,000. Equipment detail not reported.

Colo., Denver—The Moffat Tunnel Dist., Club Bldg., awarded the contract for the construction of tunnel to Hitchcock & Tinkler, Club Bldg., Arapahoe St. Estimated base cost $5,250,000. Equipment and electrification of tunnel is not included in contract but will be done by commission, estimated cost $450,000.

Conn., Middletown—The Standard Oil Co. of New York, 26 Bway., New York, awarded the contract for the construction of a distributing plant here, to the R. H. Beattie Constr. Co., Buffington Bldg., Fall River, Mass. Estimated cost $1,000,000. Noted July 24.

Ill., Freeport—The W. T. Rawleigh Co., 101 South Liberty St., awarded the contract for the construction of a 2 story, 75 x 100 ft. power plant to A. Zwack, 1301 Central Ave., Dubuque, Ia. Estimated cost $100,000. The owner is in the market for power equipment, motors, etc. Noted Aug. 21.

Ky., Louisville—The Elks awarded the contract for furnishing and installing heating, ventilating equipment, etc., in Elks' Home, 3rd and Chestnut Sts., to F. A. Clegg, 110 South 1st St., Louisville. Estimated cost $40,000.

Ky., Louisville — The Kosairs Assn. awarded the contract for furnishing and installing heating and ventilating equipment for temple on Broadway to A. J. Anderson, 338 West Main St., Louisville, $51,000. Noted Sept. 25.

Ky., Lyndon—The Kentucky Children's Home Society, 1086 Baxter St., awarded the contract for the construction of a hospital building, detention wards and boiler house to the Frey Planing Mill Co., 418 East Breckenridge St., Louisville. Estimated cost $150,000. Equipment detail not reported. Noted Sept. 25.

Mich., Lincoln Park (Wyandotte P. O.) —The Wayne County Road Comn., 1103 Real Estate Bldg., Detroit, awarded the contract for grade separation on St. Cosme Rd. and Pennsylvania Detroit Ry., including excavating, sodding and construction of pump house, sewer, etc., here, to Closser Bros., 3917 Lawton Ave., Detroit, $39,182.20. Noted Sept. 11.

N. Y., Alden—Erie County, City Hall, Buffalo, awarded the contract for the construction of a county home and infirmary here, to H. Shenk, Erie, Pa., $1,079,000. Equipment detail not reported. Noted Nov. 7.

N. Y., Lackawanna—The Bethlehem Steel Co., Bethlehem, Pa., awarded the contract for installation of electric drives to replace steam drives for the machinery of its plant, here, to the Westinghouse Electric & Mfg. Co., Union Bank Bldg., Pittsburgh, Pa. Estimated cost $250,000.

N. Y., New York—The Octo Bldg. Corp., c/o Rouse & Goldstone, Engrs. and Archts., 512 5th Ave., will build a 12 story apartment house on West 80th St., by day labor. Estimated cost $1,500,000. Equipment detail not reported.

N. Y., Oswego — The state awarded the contract for the construction of a 5 story, 69 x 213 ft. grain elevator on River St., here, to the J. Stewart Co., Inc., 30 Church St., New York, $1,119,958.83. Noted July 24.

Ohio, Cleveland—The Cleveland Laundry Co., 2840 Central Ave., awarded the contract for the construction of a 1 story, 32 x 80 ft. laundry and boiler house to the W. F. Thompson & Son Co., 5103 Euclid Ave., Cleveland. Estimated cost $40,000.

Tex., Fort Worth—The city awarded the contract for pumps and other equipment for Arlington Heights booster station to West & Womack, Dan Waggoner Bldg., Fort Worth, $10,990. Noted Sept. 25.

Tex., Fort Worth — The United States Helium Plant, c/o A. G. Olsen, Decatur Rd., awarded the contract for the construction of a factory to the Taylor Bldg. Co., Burnett Bldg., Fort Worth. Estimated cost $160,000. Contract for miscellaneous machinery, including pumps, power plant improvements, etc., was awarded to the Macbeth Eng. Co., Magnolia Bldg., Dallas.

Tex., Houston — The city and Harris County awarded the contract for the construction of a 4 story hospital to the Russell Brown Co., Carter Bldg., Houston. $182,000. Total estimated cost $270,000. Equipment detail not reported.

Wash., Seattle—The Seattle Ice Cream Co., 4th and Atlantic Sts., awarded the contract for the construction of a 2 story, 120 x 186 ft. factory to the Grant Smith Co., Henry Bldg., Seattle. Estimated cost $150,000.

Wis., Madison—The Security State Bank, 629 Atwood Ave., awarded the contract for a steam heating plant, boilers, radiation and piping for bank building to A. M. Toussaint, 1228 Williamson St., Madison. Estimated cost $25,000. Noted Aug. 21.

Wis., Monticello—The Bd. Educ., C. D. Kennedy, Secy., awarded the contract for the construction of a 50 x 95 ft. boiler house, boilers, piping, etc., for heating high school building to Karlen & Steinman, Monticello. Estimated cost $40,000.

B. C., Vancouver—The Georgia, Ltd., 657 Granville St., W. F. Evans, Pres., awarded the general contract for the construction of a 7 story, 120 x 125 ft. apartment hotel on Georgia and Hornley Sts., to Smith Bros. & Wilson, 850 Hastings St., W., Vancouver. Estimated cost $425,000. Contracts for heating system, etc., have not been awarded.

Ont., Niagara Falls—The Niagara Falls Arena, Ltd., awarded the contract for the construction of an ice rink on Victoria Ave. to the Gardner Constr. Co., Welland, $52,000. Noted Aug. 28.

Que., Montreal—Caron Bros., 233 Bleury St., awarded the contract for the construction of a 10 story, 136 x 207 ft. office building to O. Archambault, 610 Parc Lafontaine St. Estimated cost $750,000. Equipment detail not reported.